
A Baseline Inventory (1992-96) and Analysis of Natural Communities, Rare Plants and Animals, Aquatic Invertebrates, and other Selected Features in Preparation for State Forest Master Planning

Biotic Inventory and Analysis of the Northern Highland- American Legion State Forest

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Executive Summary

Project Purpose and Objectives

This report presents the results of a multi-year project to inventory and analyze selected biotic resources of the Northern Highland-American Legion State Forest (NHAL) and the surrounding landscape. This project was undertaken by the Natural Heritage Inventory (NHI) section of the Wisconsin Department of Natural Resources' (WDNR) Bureau of Endangered Resources, in cooperation with the Bureau of Forestry, to provide baseline ecological information relevant to the development of a new property Master Plan for the Forest. The information from this report will be used alongside other information on the forest and its surrounding environment to support property master planning. The primary objectives of this project are:

- The identification and evaluation of natural communities, rare or otherwise significant plant and animal populations, and selected aquatic features and their associated biotic communities.
- The identification of sites appropriate for the restoration of lost or declining communities or important habitats.
- To emphasize especially important protection, management, and restoration opportunities, focusing on both unique and representative natural features of this property and the surrounding landscape.
- The interpretation and transfer of the information gathered to the property master planning team, and ultimately to managers, administrators, and others involved in the implementation of land use decisions on the state forest.

Description of Study Area

The Northern Highland-American Legion State Forest is located in northern Wisconsin in Vilas, Oneida, and Iron Counties. The NHAL is the state's largest property, with over 220,000 acres acquired to date. The entire region was glaciated, with deep deposits of outwash and moraine creating prominent landforms. The majority of the forest lies within the Northern Highlands Pitted Outwash ecoregion, characterized by thick deposits of glacial outwash, a highly significant concentration of glacial kettle lakes, springs and headwater streams, and extensive wetlands. Soils are generally sandy, with topography varying from level to rough and rolling ("pitted" outwash). Areas along the northern edge of the NHAL are within the Winegar Moraines ecoregion and are characterized by rolling topography; richer sandy loam soils; numerous lakes and springs; and many small, forested and open wetlands.

Prior to European settlement, white and red pine forests dominated most of the pitted outwash plain of the Northern Highland ecoregion (Finley, 1976). Northern hardwood forests and conifer swamps were also common and extensive peatlands occupied depressions and the headwater areas of many streams. In the Winegar Moraine ecoregion, greater concentrations of northern hardwood forests, especially sugar maple and hemlock forests, were evident (WDNR, 1999).

Today, aspen is the most extensive cover type, with smaller amounts of northern hardwood forests, pine forests, oak forests, and pine plantations. Aspen, white birch, and pine plantation cover types account for approximately 45 percent of the total state-owned land area and over 55 percent of the forested lands on the NHAL. Lowland forest (5 percent) and "marsh" (10 percent) (bog, muskeg, fen, meadow, marsh)

cover types remain a significant component of the NHAL. We present these figures to give the reader a generalized overview of the study area's vegetation. Within any of these broad cover types, individual stands will exhibit differences in composition and in management potential.

The three counties of Iron, Oneida, and Vilas contain over 20 percent of Wisconsin's inland lakes and 20 percent of the state's inland lake acreage (WLRB, 1995). The NHAL contains over 900 lakes within its boundaries, over 6 percent of Wisconsin's total number, while the NHAL land area is barely one-half of one percent of Wisconsin's total land base (WDNR, 1982). Extensive bogs, peatlands, and swamps cover about 21% of the Northern Highlands Region. The region is an important headwater area for much of Wisconsin (the Wisconsin and the Flambeau-Chippewa) because of its relatively high elevation, great infiltration capacity, and mostly forested watershed.

An additional important characteristic of the NHAL is the forest's location and proximity to surrounding public ownerships, including the Ottawa, Nicolet, and Chequamegon National Forests, the Iron, Oneida, and Vilas County forests, two state-owned flowages (Willow and Turtle-Flambeau), state wildlife areas, state trust lands, and State Natural Areas.

Summary of Results

Several hundred sites within and around the NHAL were inventoried between 1992 and 1996 for natural communities, rare plants and animals, and aquatic features. The selection of inventory sites relied on compilation of background data, including sources both inside and outside of DNR, and involved literature review, aerial photograph interpretation, Original Land Survey Notes interpretation, NHI database review, and interviews.

Sixty-five sites, some of which are grouped within 4 macrosites, are termed **Primary Sites** and generally include the best examples of both rare and representative natural features that were documented within the NHAL. Descriptions for each Primary Site are included in Appendix B in the report. Additional sites of importance have been organized within two other categories. **Isolated Occurrences of Rare Species** are scattered inventory sites located within the NHAL boundary that contain a rare species occurrence. These sites are generally small, isolated, and not associated with more extensive natural features. **Ecologically Significant Sites Outside the NHAL** are selected inventory sites near but primarily outside of the NHAL boundary that contain significant examples of rare and representative natural features.

Rare Vascular Plants

Thirty-four rare plant species were documented on the NHAL including one WI Endangered, 3 WI Threatened, and 30 WI Special Concern species. Seventy-nine percent of the rare plants documented on the NHAL grow primarily in wet habitats, illustrating the biodiversity significance of abundant high-quality lakes, streams, and wetlands in the region. Appendix E in the report provides detailed information for each of the rare plants on the NHAL.

Rare Animals

Sixty-seven species of rare animals were documented on the NHAL, including one US Endangered, one US Threatened, one WI Endangered, nine WI Threatened, and 57 WI Special Concern species. The NHAL presents a significant opportunity to provide secure habitat for a large number of forest dependent birds, including several boreal species, and many forest interior species. As with rare plants, the high number of rare aquatic animals is a reflection of the abundance of high-quality lakes, streams, and wetlands in the Northern

Highland region. The NHAL is used by 2 known wolf packs and contributes to one of the highest known regional concentrations of bald eagle, osprey, and common loon. Appendix G in the report provides detailed information on rare animals for the NHAL.

Natural Communities

Over 200 occurrences of 22 natural community types were surveyed within the NHAL. A master list of the natural communities of the study area, brief descriptions of each type, and an assessment of the significance of each type on the property and within the region may be found in Appendix D of the report.

The following community types express major ecological themes of the NHAL landscape, and are of high conservation priority because of their extent, relatively outstanding condition, high significance to both rare and representative native species, or because relatively few other opportunities to conserve these types exist statewide:

- northern dry-mesic forest
- northern mesic forest
- open bog/muskeg/poor fen/black spruce swamp/tamarack swamp
- wild rice marsh
- aquatic features

Important Aquatic Features

One of the dominant attributes of the Northern Highland region is the high density of lakes and other aquatic habitats. Important aquatic communities include:

- seepage lakes
- drainage lakes
- spring lakes
- spring ponds
- small streams
- selected stretches of medium-sized streams
- wetlands

Key Issues for Consideration

Five key issues emerged from the analysis of the ecological findings. These are ordered according to a nested hierarchy of scales ranging from the regional to the local level, and are the highest priorities from the Biotic Inventory.

1. **Local, Regional, and Continental Significance** - The NHAL is an ecologically important site at local, regional, and even larger scales. It provides potential ecological connections to other properties (local and regional), large forested landscapes (regional and state), habitat for animals with landscape level habitat needs (regional and state), and habitat for migratory birds (state, multi-state, continental).
2. **Size and Context** - At over 220,000 acres, the NHAL is by far the largest state property. It is in close proximity to many other public and private conservation lands. This combination of large size and central location set the stage for the NHAL to play a defining role in the protection, management, and restoration of the area's most characteristic natural communities, including extensive forests, large peatlands, diverse lakes, headwater streams, and rare plants and animals.
3. **Content** – The NHAL contains some of Wisconsin's largest and least disturbed remnants of mature dry-mesic white pine-red pine and mesic hemlock-hardwood forest. The state forest occupies a central location within the Northern Highlands Pitted Outwash ecoregion, making up about 25 percent of the total area. The NHAL contains a high concentration of wetlands that are of regional importance.

Protection and management of these key features at suitable locations and at a variety of scales should be a key consideration.

The NHAL contains a significant variety of natural communities, rare plants and animals, and unique aquatic features. The 65 primary sites and 4 macrosites represent the best examples of rare and representative natural features documented and should be considered as high protection and/or restoration opportunities. In particular, 36 of the Primary Sites are of comparable significance to existing State Natural Areas (SNAs), and may represent ecological components that are missing or underrepresented from the existing SNAs.

4. **Diverse Array Of Aquatic Features** - The NHAL presents excellent opportunities to protect and manage important aquatic features, including seepage lakes, drainage lakes, spring lakes, spring ponds, and small and medium-size streams. The concentration of glacial kettle lakes is globally important. Some of the lake types are rare, and many rare aquatic plants and animals are present.
5. **Development Pressures** - Development pressures on privately owned lands within and around the NHAL are currently high and increasing, especially on shorelines of lakes and streams (Laas, 1996). Road densities within the forest boundary are high, compared to many other parts of northern Wisconsin (WDNR, 1999), and are likely to increase with additional development.

Ecological Considerations and Priorities for Master Planning

The Biotic Inventory report presents general and specific ecological considerations that emerged after careful scientific analysis of the ecological processes, biotic data, and existing land use for the NHAL. They are grouped according to conservation opportunities and challenges and restoration opportunities. In addition, ecological priorities are outlined and grouped in sections: natural resource management and protection, restoration, land use, monitoring, research, and future inventory.

Site Descriptions

Sites descriptions are located in Appendix B of the report and provide locational information, site descriptions, element occurrence information, site significance, and management considerations for each of the 66 Primary Sites and 4 macrosites. In addition, a site map for each primary site depicts occurrences of significant communities, species and aquatic features, and public ownership according to 1998 GIS public ownership coverages.

Introduction

Project Purpose and Objectives

This report presents the results of a multi-year project to inventory and analyze selected biotic resources of the Northern Highland-American Legion State Forest (NHAL) and the surrounding landscape. This project was undertaken by the Natural Heritage Inventory (NHI) section of the Wisconsin Department of Natural Resources' (WDNR) Bureau of Endangered Resources, in cooperation with the Bureau of Forestry, to provide baseline ecological information relevant to the development of a new property Master Plan for the Forest. This inventory and analysis is one of a number of assessments undertaken to prepare for state forest master planning. The information provided in these reports consolidates background information useful for property master planning and other applications and is intended to be used together to develop overall recommendations for the forest.

The primary objectives of this project were:

- The identification and evaluation of natural communities.
- The identification and evaluation of rare or otherwise significant plant and animal populations.
- The identification and evaluation of selected aquatic features and their associated biotic communities.
- The identification of sites appropriate for the restoration of lost or declining communities or important habitats.
- To emphasize especially important protection, management, and restoration opportunities, focusing on both unique and representative natural features of this property and the surrounding landscape.
- The interpretation and transfer of the information gathered to the property master planning team, and ultimately to managers, administrators, and others involved in the implementation of land use decisions on the state forest.

Future inventory and monitoring of the biotic resources of the NHAL will be ongoing and periodic, based on needs identified in the master plan and possibly elsewhere, with adjustments made to accommodate new information using the principles of adaptive management.

Background on Past Efforts

The NHI has compiled records on the occurrences of rare species and intact natural community remnants throughout the state of Wisconsin, but no comprehensive inventory had been conducted for these elements on the NHAL. During 1979-80, the Scientific Areas section of the DNR's Bureau of Research conducted inventories in Vilas, Iron, and Oneida counties to locate and assess remnant natural areas. These surveys included the NHAL but were designed primarily to identify potential State Scientific Areas and were therefore more limited in scope than the present effort.

Additional surveys have been conducted on the property and within the region by various individuals, agencies, and institutions for a variety of reasons, but most of this work was limited to specific locations and/or specific taxa. All of these data, however, have been helpful to us in assessing the adequacy of the information available to enable the development of a new property master plan.

Description of Study Area

The Northern Highland-American Legion State Forest is located in northern Wisconsin in Vilas, Oneida and Iron Counties (Figure 1). The NHAL is the state's largest property, with over 220,000 acres acquired to date. The entire region was glaciated, with deep deposits of outwash and moraine creating prominent landforms. Lakes are major natural features of this landscape, with over 900 occurring within the state forest boundary alone. Small streams, and, in some areas, spring ponds are also notable aquatic features. The Northern Highlands is the headwater area of Wisconsin's two largest drainage basins, the Wisconsin and the Flambeau-Chippewa.

The soils associated with outwash landforms are primarily sands and loamy sands. Loams and sandy loams are more prevalent on the moraines. Organic wetland soils formed from acid moss, sedge, and woody peat are common throughout the forest.

The Northern Highland now occupies the heart of one of the upper Midwest's great historic pineries. The western Great Lakes region was subjected to catastrophic logging, often followed or accompanied by severe fires, during the late nineteenth and early twentieth centuries and before state ownership. Today the landscape once again features extensive forests, but in many places deciduous trees, such as trembling aspen and paper birch have replaced the pines. At some locations, second-growth northern hardwoods stands are prominent. Wetlands are well represented in this landscape, both in acreage and diversity of types. Peatlands are especially prevalent here.

Many additional public lands occur in the vicinity of the NHAL. These include national and county forests; state recreational, fishery, and wildlife properties; state trust lands; and state natural areas. Privately owned lands with high conservation significance are also found in the study area.

Ecoregions of the NHAL

Ecoregions are geographic areas of similar physical, chemical, and biological characteristics organized within a hierarchical framework. Each level of the hierarchy shares important ecological attributes such as climate, geology, landform, hydrology, soils, and vegetation. Terminology for the ecoregions presented here follows that developed by Bailey (1995), the National Hierarchical Framework of Ecological Units (NHFEU) (Avers et al., 1994), and others. Related information on the ecoregions of Wisconsin and the western Great Lakes can be found in Albert (1995) and Hole and Germain (1994).

The NHAL is located within Province 212 - Laurentian Mixed Forests and Section 212J - Southern Superior Uplands. These broad ecoregional classifications are characterized by differences in climate, geomorphic process, geologic origin, drainage, and stratigraphy. A further subdivision of these ecoregions shows the NHAL crossing two distinct sub-sections: the Winegar Moraine and the Northern Highlands Pitted Outwash (Figure 2). The subsections, described below, are characterized by basic differences in geomorphic process, surface geology, lithology, subregional climate, and some soil and vegetation characteristics. The subsections demonstrate unifying attributes that we have found useful in planning and structuring our fieldwork. We do not use the more detailed lower levels of the system

(landtype associations - LTAs) because individual delineations and descriptions had not been completed for the forest by the time this report was printed.

Northern Highlands Pitted Outwash – Subsection 212Jm

Thick deposits of glacial outwash, a highly significant concentration of soft water glacial kettle lakes, springs and headwaters streams, and extensive wetlands, characterize this ecoregion. Soils are generally sandy, with topography varying from level to rough and rolling (“pitted” outwash). Several small drumlin fields are present. Outcroppings of bedrock are extremely rare and those noted are very small. Throughout most of this region the uplands are forested. Dominant cover types at present include aspen, paper birch, plantation-grown pine (mostly red pine), and northern hardwoods. Historically, this region was renowned for its magnificent “pinery” – vast forests of large white and red pines. Mesic hemlock-hardwood forests were significant in some areas, and paper birch and aspen were at least locally common, especially where there had been recent wildfires.

Wetlands are numerous in this ecoregion, some of them very large. Most wetlands are acidic, having accumulated layers of sphagnum peat over several millennia. Open bog, muskeg, poor fens, black spruce swamp, and tamarack swamp are common peatland communities. Other wetland types are also present, including white cedar swamp, hardwood swamp, emergent and submergent marsh, fen, sedge meadow, alder thicket, shrub-carr, and small patches of floodplain forest along the major rivers.

Winegar Moraines – Subsection 212Jc

The Winegar Moraines subsection extends into the northern edge of the NHAL. Key attributes of this ecoregion include: rolling topography; extensive mesic northern hardwoods and hemlock hardwood forests; richer, and in some areas more finely textured soils than those associated with the sandy glacial outwash area to the south; numerous lakes and springs, especially in the rough end moraine across extreme northern Vilas county; and many small, forested and open wetlands. Publicly owned portions of this ecoregion include parts of the Ottawa National Forest of the central Upper Peninsula of Michigan and the Chequamegon National Forest of northwest Wisconsin.

More detailed information on the ecoregions of northern Wisconsin is included in the DNR’s Northern State Forest Assessments (1999), particularly in the reports dealing with Regional Ecology and Community Restoration and Old-growth. Information on vegetative cover, wildlife, ownership, and aquatic features is included in these documents, and is broken down by ecoregion. Ecoregion descriptions relevant to the upper Great Lakes area can also be found in Albert (1995) and Bailey (1995).

Ecoregional Scale and Distribution

The following terms are used throughout this report to describe how various ecological components (i.e. community, species) relate to ecoregions.

Scale – within a given ecoregion, natural communities will occur (or could potentially occur) at characteristic scales or a range of scales. In the text, we have used the following terms to reference community patch sizes:

- **Matrix** – very large, continuous, and regionally driven (climate, surface geology, disturbance regime, soils). The matrix vegetation of the Northern Highland Pitted Outwash ecoregion is dry-mesic forest, historically dominated primarily by white and red pine.
- **Large patch** – large, discrete, and locally driven (local landform, topography, soil conditions). NHAL examples include mesic hemlock-hardwood forest and some open bog/muskeg communities in the Northern Highland Pitted Outwash ecoregion.

- Small patch – small, discrete, very localized. NHAL examples include boreal (rich) fen, bedrock glade, and spring pond.
- Linear – discrete, continuous, driven by local and regional processes. NHAL examples include streams, beaches, and bedrock outcroppings along an escarpment.

Distribution pattern – useful terms for referring to the geographic range of natural communities or species of concern within ecoregions include:

- Restricted/endemic – occurs primarily within a single ecoregion ($\geq 90\%$).
- Limited – shared within a few other ecoregions.
- Widespread – occurs in many ecoregions.
- Disjunct – occurs mainly in other ecoregions, separated by unoccupied regions.
- Peripheral – edge of natural range, main distribution occurs outside of ecoregion.

Hydrology

The Northern Highlands region was entirely affected by Pleistocene glaciation over 12,000 years ago. The area was reduced to a nearly level plain that in turn was buried under varying thicknesses of glacial outwash. This material is composed of sand and gravel derived mostly from igneous rock with some metamorphic and sedimentary rock. It is largely insoluble and non-calcareous. As a result, much of the seepage source surface waters, especially in the Northern Highlands Pitted Outwash ecoregion, are very low in dissolved nutrients. Geologically, the drift is classified as pitted outwash. Much of the Northern Highland Region was thought to be a calving area for icebergs as this is where the receding glacier broke into pieces (Black et al., 1963). These icebergs became buried in the drift and, upon melting, formed deep pits or kettles. Many of these filled with water to form the abundant lakes of the region, making the Northern Highland ecoregion one of the most concentrated lake districts in the world. Moraine landforms composed of glacial drift materials exist in the region, including the large end moraine in Vilas County (Winegar Moraines ecoregion) and several small moraines scattered throughout the region.

The three counties of Iron, Oneida, and Vilas contain over 20 percent of Wisconsin's inland lakes and 20 percent of the state's inland lake acreage (WLRB, 1995). The NHAL contains over 900 lakes within its boundaries, over 6 percent of Wisconsin's total number, while the NHAL land area is barely one-half of one percent of Wisconsin's total land base (WDNR, 1982). Extensive bogs and swamps that formed in poorly drained depressions cover about 21% of the Northern Highlands Region.

The many lakes and wetlands store surface water and release it to streams slowly over extended periods of time. Peak runoff is attenuated and high base flows are prolonged by basin and wetland storage from the shallow water table, but are reduced during long drought periods. Many of the lakes in this area are classified as sensitive to acid precipitation because of very low alkalinity. The region is an important headwater area for much of Wisconsin because of its relatively high elevation, great infiltration capacity, and mostly forested watershed.

Generalized Land Cover

The boundary of the NHAL encompasses approximately 220,000 acres of state-owned land, of which over 75 percent is covered by forested vegetation (WDNR, 1999a). Prior to European settlement, white pine and red pine forests dominated most of the pitted outwash plain of the Northern Highland ecoregion

(Finley, 1976). Northern hardwood forests and conifer swamps were also common and extensive peatlands occupied kettle depressions and the headwater areas of many streams. In the Winegar Moraine ecoregion, greater concentrations of northern hardwood forests, especially sugar maple and hemlock forests, were evident (WDNR, 1999). Figure 3 shows the distribution of forest cover types prior to European settlement (Finley, 1976).

Today, the vegetation pattern of the NHAL has changed considerably (Figure 4). Aspen is the most extensive cover type, with smaller amounts of northern hardwood forests, pine forests, oak forests, and pine plantations. Table 1 depicts the current acreage figures for each land cover type for state-owned lands only (NHAL Forest Compartment Reconnaissance, 3/2/99). Aspen, white birch, and pine plantation cover types account for approximately 45 percent of the total state-owned land area and over 55 percent of the forested lands on the NHAL. Lowland forest (5 percent) and “marsh” (10 percent) (bog, muskeg, fen, meadow, marsh) cover types remain a significant component of the NHAL. We present these figures to give the reader a generalized overview of the study area’s vegetation. Within any of these broad cover types, individual stands will exhibit differences in composition and in management potential.

In addition to the change in cover type composition, a number of presettlement ecological attributes are missing from or diminished in the current NHAL forest. Old-growth forests of all communities and including remnants of the northern Wisconsin pinery are few, generally widely scattered, and of limited size. Upland conifer forest types, especially white and red pine cover types, have decreased in acreage as aspen and other cover types have increased. Road and utility corridors, residential development, and various management practices impact large patches of continuous forest cover. The attributes of old-growth, extensive upland forests, and large community patches increase landscape level diversity and accommodate functional, structural, and compositional needs of many plants and animals (Matthaie, 1993).

Figures 3 and 4 were developed using Original Vegetation and Land Use/Land Cover (LULC) GIS coverages from the Bureau of Information Management of the Wisconsin Department of Natural Resources. More detailed maps of both coverages are available and have been used in other Northern Forest Assessments. In an effort to provide a general picture of both presettlement and current vegetation for the NHAL, and to make both coverages more compatible, we employed a combination of level one and level two classifications for the LULC coverage. Generalizations, inaccuracies, and interpretation difficulties are inherent in the resultant Current Vegetation map of Figure 4.

A listing of all known vascular plants within the NHAL is included in Appendix F.

Table 1. Cover Types for State-Owned Lands in the Northern Highland-American Legion State Forest

<i>Forest Cover Type*</i>	<i>Sub-total</i>	<i>Total</i>	<i>Percent</i>
Aspen		73,147	33.7%
Northern Hardwood		18,727	8.6%
▪ Hemlock-Hdwd	3,351		
▪ Red maple	272		
▪ Northern Hdwd	15,104		
Natural Pine		17,465	8.0%
▪ Jack pine - natural	2,680		
▪ White pine-natural	6,986		
▪ Red pine-natural	7,799		
Oak		15,540	7.2%
Pine plantation		13,379	6.2%
▪ Jack pine-plantation	4,364		
▪ Red pine-plantation	8,427		
▪ White pine-plantation	588		
White birch		10,801	5.0%
Lowland Conifer		9,137	4.2%
▪ Cedar	1,958		
▪ Black spruce	5,844		
▪ Swamp conifer	737		
▪ Tamarack	598		
Lowland hardwood		899	0.4%
Fir-Spruce		1,960	0.9%
Scrub Oak		1,031	0.5%
Other		8,521	3.9%
Sub-total of Forested Acres:		170,607	78.7%
Marsh		21,512	9.9%
Grassland		12,546	5.8%
▪ Upland grass	3,636		
▪ True Grasses	31		
▪ Herb vegetation	1,148		
▪ Noncomm grass	10		
▪ Lowland brush	7,484		
▪ Upland brush	217		
▪ Rock outcrops	20		
Emergent vegetation		225	0.1%
Alder		170	0.1%
Muskeg bog		76	<0.1%
Water		3,233	1.5%
Other		8,440	3.9%
Sub-total Non-forested Acres:		46,202	21.3%
TOTAL ACRES:		216,809	100.0%

Source: Northern Highland-American Legion State Forest Compartment Reconnaissance – March 2, 1999

* Forest Reconnaissance is a coarse filter approach classifying forest cover types. The name of a cover type reflects the dominant vegetation in forest stands. Within any of these cover types, individual stands will exhibit differences in composition and in management potential.

Lands Surrounding the NHAL

The Northern Highland is situated amid, and in some cases, adjacent to, numerous other public ownerships (Figure 5). These lands include the Ottawa, Nicolet, and Chequamegon National Forests, the Iron, Oneida, and Vilas County forests, two state-owned flowages (Willow and Turtle-Flambeau), state wildlife areas, state trust lands, and state natural areas.

While management emphasis on most of these lands is focused on timber products and recreation, each property makes contributions to the maintenance of regional diversity. Many of these lands have been at least partially surveyed for rare plants and animals and unique natural communities.

Very significant natural features are also known to occur on private lands (including tribal lands) in the NHAL landscape. These have not generally been identified on the maps.

Overview of Methods

Natural Heritage Inventory Overview

The NHAL inventory and analysis were conducted by the Wisconsin Natural Heritage Inventory program, which is part of an international network of NHI programs. The defining characteristic of this network, and the feature that unites the programs, is the use of a standard methodology for collecting, processing, and managing data on the occurrences of natural biological diversity. This network of data centers was established, and is currently coordinated by, The Nature Conservancy, an international non-profit organization.

Natural Heritage Inventory programs focus on rare species, natural communities, and other rare elements of nature. When NHI programs are established, one of the first tasks facing the staff is to consolidate existing information on the status and location of rare elements. Before proceeding, the NHI program must determine what elements warrant "tracking" and which are more common. Similar to most states, Wisconsin biologists had a general idea of which species in the better-studied taxonomic groups (e.g., mammals, birds, and vascular plants) were rare or declining. For less-studied groups such as macroinvertebrates, the process of assembling the list of species to track and gathering the data were quite dynamic. Initially, NHI staff cast a wide net, collecting data on many species from existing sources (e.g., scientific literature, field guides, books, maps, and museum collections) as well as from direct contact with experts throughout the state. As more data were gathered, it was clear that some species were more common than originally thought and the NHI program stopped collecting data on them. Thus, the list of which elements are tracked, the NHI Working List, changes over time as species' populations change (both up and down) and as our knowledge about their status and distribution increases. This evolution continues today, with the NHI Working List typically going through several revisions a year. The current Wisconsin Natural Heritage Working List for the State of Wisconsin dated March 17, 1999 is found in Appendix I.

In general, there are two approaches to surveying biodiversity: (1) those focused on locating occurrences of particular elements, and (2) those focused on assessing the components of a particular area. The latter approach employs a "top down" analysis that begins with an assessment of the natural communities and

aquatic features present, their relative quality and condition, the surrounding landscape pattern, and current land use and results in the identification of future species-oriented surveys. This approach, commonly referred to as “coarse filter-fine filter,” concentrates inventory efforts on those sites most likely to contain target species. It also allows sites to be placed in a larger, landscape context for more broad applications of ecosystem management principles.

The NHAL inventory used the top-down, coarse filter-fine filter approach. The initial analysis assessed the entire region and determined the important ecological attributes and the biological processes supporting them. Criteria to evaluate sites were established and then vegetative communities were identified and characterized. Based upon existing habitat characteristics and known habitat preferences of various rare species, sites where species-specific surveys were most appropriate were identified. ***No doubt, occurrences of rare species exist that were not located through these inventories.*** However, by concentrating inventory efforts on the highest quality or otherwise suitable sites, it is most likely that the populations with the highest conservation value were located.

The NHI methodology for organizing and storing data is actually a system of three inter-related data storage techniques: structured manual information files, topographic map files, and a computer database that integrates the various information. The computer component, known as the Biological & Conservation Data System (BCD), was developed by The Nature Conservancy for use by the Heritage Network. It is a sophisticated relational database management application built upon the Advanced Revelation application environment. Owing to the diversity and complexity of the information managed--from species taxonomy and ecosystem classification to real estate transactions--the system contains 36 database files and more than 2,000 information fields. The data in the Biological & Conservation Data System populate the NHI Geographic Information System.

Field Surveys

Reconnaissance surveys were conducted on the NHAL in 1992 by NHI ecologist Eric Epstein and Randy Hoffman. These preliminary surveys identified those natural communities, aquatic features, and rare priority taxa warranting a more detailed inventory. Various experts conducted comprehensive inventories during 1992-1995. Certain species groups received relatively less attention than others. These include fish, mammals, non-vascular plants, and some invertebrates (especially terrestrial invertebrates). Reasons include: 1. insufficient existing data; 2. too little was known about a group to interpret the information gathered within the context of a DNR property master plan; and 3. the assumption was made that a “coarse-filter” community-focused approach to protection will conserve a significant portion of the unsurveyed taxa.

A limited number of surveys were conducted in 1996 to fill gaps in phenology and to more thoroughly cover some sites. Standard NHI methodology was used along with accepted protocol and procedures for the various taxa. Prior to entering the field, the following methods were used to assess the biological diversity of the NHAL. The methods are explained in greater detail in Appendix A. Detailed discussions of the field survey methods for natural communities, plants, and animals are in Appendices D, E, and F, respectively.

- Compilation of existing file information on the study area from sources both within and outside of the DNR.
- Literature review.
- Development of a target list of natural communities, rare plants and animals, waterbodies, and other significant natural features for the study area.
- Map compilation and development of a base map of the study area.
- Aerial photograph examination and interpretation.

- Original Land Survey Notes examination and interpretation.
- Interviews with experts (scientists, naturalists, land managers) knowledgeable about the study area.
- Information sharing among project participants.
- Aerial reconnaissance (fly-over).
- Analysis of information gathered and project planning.

Data Analysis and Site Identification

Following completion of our field work and the computerization of the collected data, the Natural Heritage Inventory conducted a staff workshop to evaluate the significance of the natural features we had surveyed from both local and statewide perspectives, and to identify those sites that encompassed the most significant features. Fred Clark of Clark Forestry, Inc. led the workshop and used techniques developed for similar evaluations in the Baraboo Hills of south central Wisconsin for The Nature Conservancy and the Brule River State Forest for DNR. Participants in this workshop were leaders for the NHI botany, zoology, and ecology programs. Staff from the Bureaus of Forestry, Facilities and Lands, and Science Services observed the process. The evaluations were guided by ranking factors such as: the number of populations of a rare species on the State Forest relative to the number known to occur statewide; the size of the populations on the NHAL compared to those elsewhere; the need for active management to provide for the long-term viability of rare species populations or natural communities; the extent, quality, and condition of the natural communities on the NHAL compared to those in the region; the degree to which inherent or potential ecological conditions on the planning unit (here the NHAL) increase the viability or defensibility of the rare species population or natural community; and the sensitivity of the rare species or community to management actions.

We consulted many sources to aid in the identification and prioritization of sites in and around the State Forest. Our basic references included the Bureau of Forestry's stand/compartments reconnaissance, interpretations of local and regional land cover from recent aerial photographs and satellite imagery, the original land survey notes for the region, and habitat type information newly derived from available data on landform, vegetation, and soils.

Other inventory work conducted recently in the northern and northwestern Wisconsin region (including Wisconsin's Lake Superior basin, the Apostle Islands, the Brule River State Forest, the St. Louis River Estuary, and the Chequamegon-Nicolet National Forest, among others) gave us a solid basis for comparison and interpretation of the NHAL data.

Finally, individuals are encouraged to submit records for rare plants and animals that are on the NHI Working list. Such information is included in the NHI database on a regular basis, pending a determination of its validity. Additional information on how to submit data can be obtained from the WIDNR-BER in Madison, Wisconsin.

Summary of Results

The Results section summarizes the findings of this study according to sites, natural communities, important aquatic features, and rare plants and animals and concludes with a discussion of the key ecological factors and processes occurring in the NHAL. Each of the groupings is summarized here but discussed in more detail in Appendices B, D, E, and F.

Sites

Inventory sites were identified within and around the NHAL and surveyed by NHI field biologists during 1992-96. Site files are maintained in the NHI offices in Madison, WI and include details on flora and fauna, data sheets, maps, aerial photographs, and other information.

The significance of each site was evaluated during the Ranking Workshop (see Methods section) according to the condition, quality, and extent of the natural communities present; the number and size of the rare species populations; and the ecological context of these features. Many of the sites inventoried were found to be of relatively low significance by these criteria: they either had been greatly disturbed, supported only widespread or generalist species, or contained features for which better examples occur elsewhere in northern Wisconsin. Such lands included pine plantation monocultures, even-aged aspen stands, and certain natural communities.

These lands of lower significance do possess economic, recreational, and ecological values and may also deserve consideration for long-term restoration or other special management designation depending on site potential, condition, and context. Their management can significantly impact surrounding lands. Therefore, management decisions for forest production or other intensive uses should be considered as carefully as for the more ecologically sensitive areas.

Sixty-five sites, some of which are grouped within 4 macrosites, contained some feature of significance that raised their importance over the remaining sites as determined through the Ranking Workshop. Termed Primary Sites, they generally include the best examples of both rare and representative natural features that were documented within the NHAL. The location of each Primary Site is shown on Figure 6. Additional sites of importance have been organized within two other categories: Isolated Occurrences of Rare Species and Ecologically Significant Sites Outside the NHAL. These categories are defined below and illustrated on Figure 7 and Figure 8:

1. **Primary Sites** - Selected inventory sites within the NHAL that contain the best examples of rare and representative natural features that were documented. All or significant portions of these sites should receive high protection and/or restoration consideration.
2. **Isolated Occurrences of Rare Species** - Scattered inventory sites located within the NHAL boundary that contain a rare species occurrence. These sites are generally small, isolated, and not associated with more extensive natural features. Protection priority will depend on the significance of each population at local and regional scales, and the feasibility of maintaining or enhancing that population (Figure 7).
3. **Ecologically Significant Sites Outside the NHAL** - Selected inventory sites near but primarily outside of the NHAL boundary that contain the best examples of rare and representative natural features that were documented. Natural communities, rare species populations, and aquatic features are represented. Sites in this category have similar significance to the primary sites, but

are located outside of the NHAL boundary (Figure 8). A listing of the Ecologically Significant Sites Outside the NHAL is provided at the end of Appendix B.

Site descriptions for each of the 65 sites and the 4 macrosites are found in Appendix B and organized according to the above categories. Information in Appendix B includes:

- location information,
- a site map showing occurrences of significant communities, species and aquatic features, and public ownership according to 1998 GIS public ownership coverages,
- a brief summary of the natural features present,
- the site's ecological significance (including a table of element occurrences), and
- management considerations.

Each site map¹ shows the site location against a background of a scanned USGS topographic quadrangle. The scale of the maps varies from 1:18,000 to 1:49,000 depending upon the size of each site and information presented (original USGS resolution is 1:24,000). Occurrences of rare or endangered species or natural communities are portrayed as dot symbols. Only those species or communities within the site or within 200 meters of the site boundary are portrayed in order to emphasize their location(s) relative to the boundary. Note that there may be more than one occurrence of one or more species or communities represented by any single "dot" (or symbol), that these symbols may overlap, and that the significance of the site is not based only on the presence of rare species occurrences. The area of land the species or community occupies is frequently much larger than the dot representation. Non-DNR owned lands were obtained from a 1998 DNR GIS public lands coverage. The coverage does not represent legal ownership boundaries and may encompass errors in presentation.

Appendix C includes a master list of each of the 65 sites and the element occurrences that are located in or near them.

Site List and Characteristics

Table 2 is an overview of each of the 65 sites and the 4 macrosites. A summary of the local and regional significance of each site is provided and serves to prioritize the sites at these two landscape levels. General comments are provided on management and other issues. Full sites descriptions and management considerations are provided in Appendix B. The primary sites are arranged geographically, from the northwest corner of the NHAL to the southeast corner, and numbered to correspond with Figure 6.

¹ The maps should not be reproduced except by permission from the Bureau of Endangered Resources. These maps are for illustrative purposes only.

Table 2. Overview and Significance of Sites

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Primary Sites			
Catherine Lake Hemlock-Hardwoods (1)	High	High	Extensive, mature mesic hardwood, hemlock-hardwood forests (with patches of old-growth) on moraine; undisturbed wetlands and ponds; rare plants and animals.
Lower Manitowish River Macrosite <ul style="list-style-type: none"> • North Bass Lake and Hemlocks and Bog (2) • Du Page Lake and Pines (3) • Sugar Lake (Plunkett Lake) (4) • Manitowish River Wilderness Area (5) • Sandy Beach Lake and Bog (6) 	High	High	Large peatland complex of open bog, muskeg, spruce-tamarack swamp, drained by lower portion of the Manitowish River. Mature stands of red pine-white pine, old-growth hemlock "islands" with white pine super canopy. Sedge meadow, and emergent marsh border the river, which supports significant aquatic life. Several undeveloped seepage lakes present, at least two of which support rare aquatic organisms. Linked to other ecologically valuable sites outside the state forest boundary. Numerous rare species.
Sherman Lake (7)	High	High	Large undeveloped seepage lake, good quality wetlands; adjacent to other highly significant features.
Toy Lake Cedar and Ash Swamp (8)	High	High	Excellent natural features complex, with highly significant, large stands of swamp conifers (cedar); swamp hardwoods, plus mature hemlock-hardwood forest with old-growth characteristics. Rare plants and animals present.
Papoose Creek Pines (9)	Medium	Medium	Maturing stands of dry to dry-mesic forest composed of jack pine, red pine, white pine. Natural stands are intermingled with plantations. Near the creek, forest has a spruce-fir component. Uncommon birds associated with extensive conifer forests present.
Rice Creek Complex (10)	High	High	Exceptional site with excellent, extensive cedar swamp, spruce swamp, emergent marsh, plus old-growth hemlock stands with white pine supercanopy, northern fens, undeveloped seepage lakes. High concentration of rare plants and animals.
Highway 51 Meadow and Pond (11)	Medium	Low	Small but good quality poor fen, large population of rare plant.
Manitowish River (12)	High	High	River is a good example of medium-sized stream; few developments; diverse aquatic biota with rare species.

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Day Lake (13)	High	High	Large, undeveloped deep seepage lake with ultra-soft water, unusual flora.
North Creek - Trout Springs (14)	Low	Low	Managed spring and headwaters stream. Several rare plants occur in the adjoining wetlands.
Grassy Lake (15)	Medium	Low	Drained lake is a very good example of type; bordered by mosaic of undisturbed wetlands; limited development.
High Lake Spruce-Balsam Forest (16)	Low	Low	Small stand of mature, second-growth dry-mesic to mesic forest occurs at interface of end moraine and outwash landforms. Surrounding lands have good restoration potential and could provide an ecologically significant link to important features to the north and south.
Garland Creek Hemlocks (17)	Low	Low	Small, selectively cut hemlock stands, which are uncommon in local landscape. Surrounding forest is young hardwoods type.
Northeast Springs - Johnson Creek Macrosite <ul style="list-style-type: none"> Johnson Lake and Barrens (18) Johnson Creek and Pines (19) 	High	High	Good examples of bracken grassland, an undisturbed drainage lake and associated wetlands, and dry forest of unusual composition. The headwaters of the Flambeau-Chippewa River system consists of a unique complex of soft water springs above Johnson Lake. Restoration potential for dry forest community.
Nixon Lake Complex (20)	High	High	Undeveloped drainage lake, outlet stream, undisturbed peatlands; support several rare species. Uplands are managed aspen, natural pine forests. Pine restoration potential.
Partridge Lake Connection (21)	Medium	Low	Lake, outlet stream, and extensive peatlands provide ecological link between Nixon Lake and the Star Lake Crescent Macrosite.
Star Lake Crescent Macrosite <ul style="list-style-type: none"> Lake Alva Hemlock-Hardwoods (22) Lake Laura - Salsich Lake (23) Plum Lake Hemlock Forest (24) 	High	High	Outstanding large complex of old-growth and mature mesic hardwood and hemlock forest; undeveloped seepage lakes, and kettle wetlands. Rare plant and animal species occur here. Hemlock reproduction is locally strong. Excellent opportunity to protect and link high quality mesic forest patches.
Wharton Lake Bog Complex (25)	Low	Low	Open bog and muskeg of good quality within intensively managed upland birch/aspen forest. Some pinery restoration potential.

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Aurora Lake and Wetlands (26)	High	High	Excellent drainage lake, with significant wetlands of several types. Small stands of maturing pine forest. Outlet stream supports significant aquatic biota. Consider upland pine restoration.
Mary Davis Ries Bogs (27)	Medium	Medium	Small kettle bogs, representative features of the Northern Highland landscape, that support rare aquatic invertebrates.
Frank Lake and Frost Pocket (28)	Medium	Medium	Large undeveloped seepage lake; dry kettle depression that will not support forest due, apparently, to microclimatic conditions and, possibly, other factors.
Blueberry Lake (29)	Low	Low	Small kettle bog with representative flora. Rare species present.
Plum Creek (30)	Medium	Medium	Small, 4 mile long stream connecting two lakes; supports diverse aquatic biota with several rare species; minimal development, managed for game fish.
Central Highland Macrosite <ul style="list-style-type: none"> • Escanaba Lake Hemlocks (31) • Lost Canoe Hardwoods (32) • Stevenson Creek and Pines (33) • Allequash Lake and Pines (34) • Little John Junior Lake (35) • Benedict - Hurrah - Scaffold Lakes Complex (36) • Dry Lake and Pines (37) • Bittersweet Lakes Complex (38) • Mud Creek Springs (39) • Sweeney Lake Area (40) 	High	High	This extensive site occupies the heart of the Northern Highlands Pitted Outwash ecoregion and contains excellent examples of many of the region's most representative natural communities and aquatic features. These include dry-mesic white pine-red pine-red oak forests, mesic hemlock-hardwood forests, many undeveloped lakes, (including ultra-soft water seepage lakes), and a variety of wetland communities. Some of the individual features were evaluated as among the best examples of their respective types. The key issue is that they occur within a matrix of unbroken upland forest with few plantations or intensively managed aspen stands. Restoration opportunities are excellent and linkages to other features, especially to the north and east, could easily be created. Many rare species occur here.
Trout River (41)	High	High	Hardwater stream supports exceptional aquatic biota, with high diversity, rare species.
East Ellerson Lake and Drumlin (42)	Medium	Medium	Primary site features are undeveloped drained lake and drumlin with second-growth red oak forest.
Sparkling Creek Cedars (43)	Low	Low	Cedar swamp - alder thicket drains to Trout River. Several rare species were documented, but overall condition of the forest is poor due to beaver activity, browse, historic logging.

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Camp Lake and Pines (44)	High	High	Ultra-soft, deep seepage lake; small stand of "older-growth" white pine-red pine forest; undisturbed acid kettle bog with open bog and muskeg border. Several rare species present.
Devine Lake - Mishonogan Creek (45)	High	High	This unusual, alkaline drained lake is fed by numerous springs, and drained by an undeveloped stream. An exceptional concentration of rare plants occurs here and the aquatic biota is also significant.
Black Tern Bog (46)	Medium	Low	Small boggy kettle wetland along highway 51 contains good quality poor fen community with diverse flora. Used for educational purposes.
Vandercook Lake and Pines (47)	Medium	Medium	Mature dry-mesic forest of white and red pine, red oak, and paper birch occurs north of lake, several rare species present. Site has restoration potential.
Mann Creek Pines (48)	Low	Low	Small stand of mature, dry-mesic white pine-red pine forest borders county highway; managed peatland complex.
Trout Lake Conifer Swamp (49)	Medium	Low	Small stand of mature, wet-mesic white cedar forest adjoins Trout Lake; receives educational use. Diverse ground layer.
Trout Lake Pines (50)	Low	Low	Small linear stand of old-growth white and red pine borders good example of inland beach on Trout Lake.
Hemlock Lake (51)	Medium	Medium	Mature mesic hemlock, hemlock-hardwood forest with some old-growth attributes; undeveloped seepage lake occur on outskirts of Woodruff.
Timberlane Pines (52)	Medium	Low	Mature, older, dry-mesic forest of white and red pine was partially salvaged following recent windstorm damage. Isolated by highway 47; private developments on shoreline.
Zottle Lake (53)	Low	Low	Small, undeveloped deep seepage lake bordered by second-growth dry-mesic hardwood forest.
Tomahawk Lake Hemlocks (54)	Medium	Medium	Mesic hemlock forest with locally strong hemlock reproduction, mature dry-mesic pine-oak forest, undeveloped lake shoreline, and small kettle peatlands

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Horsehead Lake Pine-Oak Forest (55)	Medium	Low	Mature to maturing forest of white pine-red pine-paper birch-red oak-red maple, borders undeveloped shoreline of large lake. Site is isolated by roads, other factors. Several rare animals were documented here.
Two Lakes Pine-Oak Forest (56)	Medium	Medium	Mature, dry-mesic white pine-red pine forest has old-growth characteristics and undeveloped lake shoreline. Also, small patches of older hemlock forest. Somewhat isolated by private developments, ownership pattern.
Wind Pudding Lake (57)	High	High	Unusual seepage lake with diverse basin characteristics supports rare plants and aquatic invertebrates.
Hawk Lake (58)	Low	Low	Small kettle bog complex features showy, representative bog flora. Surrounding uplands are managed; may have some restoration potential.
McNaughton Conifer Swamp (59)	Medium	Low	Large acid conifer swamp of black spruce-tamarack supports boreal bird community, representative flora. Limitations include rights-of-way crossings. Most of site is outside of forest boundary.
Rainbow Wetlands (60)	High	High	Bordering the Rainbow Flowage, this peatland complex of several thousand acres consists of open bog, muskeg, sedge meadow, and shrub-carr. Small sandy islands and ridges support jack pine, red pine forest. Rare plant and animal species occur here.
Big Swamp (61)	High	High	Large acid peatland complex of open bog, muskeg, poor fen, and sedge meadow contains undeveloped seepage lake, small islands of mature white and red pine and rare plant and animal populations.
Swanson Lake and Pines (62)	High	High	This complex of undeveloped seepage lakes and associated peatlands borders a mature dry-mesic forest of red and white pine-red oak-red maple. Many rare plants occur here.
Pickrel Lake (63)	Medium	Medium	Undeveloped drainage lake, small acreage of undisturbed wetlands, and small mature stand of red pine-white pine.
Shallow Lake (64)	High	High	Undeveloped lake contains exceptional concentration of rare species and undisturbed peatlands.

Site Name (Map ID #)	Significance within NHAL	Ecoregional Significance Province/Subsection	Comments
Stone Lake Pines (65)	Medium	Medium	Very small but intact old-growth pine "islands" within undisturbed acid peatland.

Natural Communities

Over 200 occurrences of 22 natural community types were surveyed within the NHAL. A master list of the natural communities of the study area, brief descriptions of each type, and an assessment of the significance of each type on the property and within the region may be found in Appendix D. The following section identifies conservation opportunities and priorities for each of the community types. An underlying consideration is that context is frequently a key factor to consider in planning; thus the ecological values and management/protection options for a given site should generally not be considered in terms of a single community.

High Priority Conservation Opportunities

Especially good opportunities to protect and manage the communities listed below now exist on the NHAL. These community types express major ecological themes of the NHAL landscape. They were selected because of their extent, relatively outstanding condition, high significance to both rare and representative native species, and because few other opportunities to conserve these types exist statewide.

- **northern dry-mesic forest** (white pine - red pine - red oak - red maple): Highly significant protection/restoration/management opportunities occur on the forest. Issues to address in the planning process include old-growth, patch size, fragmentation impacts, connectedness, fire ecology, and appropriate silvicultural and other methodologies.
- **northern mesic forest** (hemlock - sugar maple - yellow birch): Though not the major upland forest community on the property, excellent occurrences were documented, some with old-growth attributes, and among these are some of the largest such remnants in the northern Wisconsin landscape.
- **open bog/muskeg/poor fen/black spruce swamp/tamarack swamp** (sphagnum mosses - ericaceous shrubs - sedges - black spruce-tamarack): Extensive acreages of good quality acid peatlands occur on the Highland and some adjoining properties. These communities merit increased protection, as all of the larger sites have been somewhat altered or compromised by various developments. A number of specialized plants and animals occur only in the peatlands.
- **wild rice marsh**: No longer common throughout Wisconsin, this emergent marsh type is represented by excellent occurrences on and around the forest.
- **aquatic features**: The NHAL presents exceptional opportunities to protect and manage a diverse array of aquatic features including seepage lakes, drainage lakes, spring lakes, spring ponds, small streams, and selected stretches of medium-size streams such as the Manitowish and Wisconsin Rivers. Aquatic ecosystem protection is one of the highest conservation priorities in this region. See Appendix D for the NHI classification of lakes and streams and type definitions.

The following natural community types are widespread in northern Wisconsin, and in some cases, more common outside of the NHAL. However, excellent occurrences in terms of size, context, condition, and diversity were documented on the NHAL and these merit careful conservation attention.

- **northern wet-mesic forest** (white cedar - balsam fir): Uncommon in the NHAL, 2 exceptional, large occurrences were documented. Both are very diverse, supporting many representative and rare species.
- **northern hardwood swamp** (black ash): One large, exceptional occurrence was documented. This type is vastly underprotected in northern Wisconsin.
- **boreal fen** (rich fen): Rare on the NHAL and apparently uncommon throughout Wisconsin, several excellent stands were identified. Each is an unusually rich repository of rare plants.

- **emergent aquatic** (bulrush - bur-reed - arrowhead - pickerelweed): Widespread in the state and region, particularly good opportunities exist on the NHAL to protect shoreline marshes because of the many lakes and numerous, small low-gradient streams.
- **submergent aquatic** (pondweeds - waterweed - bladderwort): Status same as above, but often better developed in deeper water than the emergent community type. They commonly co-occur.
- **northern sedge meadow** (sedges - bluejoint grass): Widespread in the north, this herbaceous wetland community may border streams, and in a few cases, lakeshores in the NHAL. Several large high quality occurrences were documented.
- **inland beach**: Many examples, some with rare species, are located on the NHAL. As shoreline development pressures continue to increase in northcentral Wisconsin, further surveys may be warranted.
- **bracken grassland** (bracken fern - sweetfern - grasses): The origins of this type are not well understood. Several good examples occur on the forest.

Additional Protection/Restoration/Management Opportunities

The following types are also widespread, but generally don't require special conservation attention because they typically occur as inclusions in wetlands containing types listed in the high priority category above:

- **shrub-carr** (willow - dogwood shrub swamp): Occurs throughout much of Wisconsin and is more common in the south. Several large stands of good quality were documented on the NHAL.
- **alder thicket**: Very widespread and common in northern Wisconsin, often in linear stands along a stream or lake border, at the interface of forested and herbaceous wetland types, or at an upland-wetland margin.

The following community types are not well represented on the NHAL, but individual stands may be of interest because of their context, local rarity, or disjunct distribution.

- **floodplain forest** (silver maple - green ash - box elder): This deciduous wet forest community is much more prevalent further south. Small stands occur along the Wisconsin and Manitowish Rivers, sometimes associated with other ecologically important features.
- **boreal forest** (white spruce - balsam fir): Only small, often-degraded remnants of this type were found. This community is pushing its southern range limits in this ecoregion and is neither extensive nor widespread.
- **bedrock glade**: Only one, very small rock outcropping was surveyed on the Forest.
- **pine barrens** (jack pine - blueberry - prairie grasses - forbs): No stands of this globally imperiled community were documented on the NHAL. Stands previously identified as barrens are more appropriately classified as "bracken grasslands," given their previous and present vegetative cover, and the absence of a sand prairie component.

Important Aquatic Features

One of the dominant attributes of the Northern Highland region is the high density of lakes and other aquatic habitats. Appendix D contains the NHI aquatic classification system. Soft-water (MPA < 50) seepage lakes (Lake- deep/shallow, soft, seepage) are particularly well developed on the NHAL and have a wide range of sizes and depths. A special feature of the Northern Highland Region is the concentration of very soft (MPA 1-20) seepage lakes (Lake – deep, very soft, seepage). These lakes feature a unique

aquatic community characterized by a number of aquatic plants that exhibit a sterile rosette growth form carpeting the lake bottom. A number of rare invertebrates are found in these lakes as well. Large firm bottomed lakes (Lake- deep, drainage and Lake- deep, seepage) are common on the forest. An interesting feature of these lakes is that they occasionally provide habitat for animals that are typically “lotic” (stream dwelling). The NHAL offers perhaps the only opportunity to protect these large, intact, deep lakes with firm bottoms - a type facing especially strong development pressure in northern Wisconsin.

Small streams (Stream - slow/fast, warm) originating in or connecting lakes are common on the forest, but feature few rare species. These streams, however, support excellent examples of macroinvertebrate communities dominated by filter feeding and collecting/gathering detritivores. Only portions of the Wisconsin and Manitowish Rivers represent larger non-wadeable streams (Streams- slow, hard, warm). However, these two streams feature a number of rare fish and invertebrates found nowhere else on the NHAL. Spring ponds (Spring pond) are characteristic of a small portion of the NHAL and are generally the source of the 12-13 trout streams (Stream- slow/fast, cold, soft/hard) found here.

A wide variety of wetland habitats are found on the forest including open bog, forested bog, sedge meadow, emergent and submergent aquatic plants, hardwood swamp, white cedar swamp, and fen. Protection of existing wetlands in good condition is critical to the maintenance of high water quality and sufficient water quantity. The wetlands are also necessary components of the habitats of many organisms, some of which have aquatic life stages.

Rare Plants and Animals

“Rare” plant and animal species are treated here as native species known or suspected to be rare and/or declining in the state. Included are species legally designated as “Endangered” or “Threatened” by either the State of Wisconsin or the federal government, as well as species in the Department’s advisory “Special Concern” category and on the U.S. Fish & Wildlife Service’s “Candidate” and “Species of Concern” lists. Rare species information for the NHAL was compiled from existing records in the BER NHI Biological Conservation Database (BCD), field inventories, and other data sources as described in Appendices E (plants) and F (animals). As a result, the dates of last observations will vary greatly between species. An older, historic record does not necessarily mean the species no longer exists on the NHAL, only that it was not encountered during the inventory completed for this report.

The full listing of rare plant and animals occurring on the NHAL is provided in Appendices E and G, respectively. A discussion of the species at each individual primary site is provided in the site descriptions in Appendix B. However, discrepancies of rare species may exist between the site narratives, site tables, and other appendices for the reasons listed on page B-1 in Appendix B.

Rare Vascular Plants

The Wisconsin Natural Heritage Database lists 34 rare plant species on the NHAL. Moor rush (*Juncus vaseyi*) is listed as Endangered in Wisconsin, and Calypso orchid (*Calypso bulbosa*), shore sedge (*Carex lenticularis*), and algae-like pondweed (*Potamogeton confervoides*) are listed as Threatened in Wisconsin; all were documented on the NHAL. Thirty additional rare plant species found on the NHAL are designated of “special concern,” meaning experts suspect a problem in their abundance or distribution, but have not yet gathered proof of threats to their survival in Wisconsin. Appendix E provides detailed information for each of the rare plants on the NHAL.

Seven of the 34 rare species grow predominantly on upland sites. The remaining species grow in wetlands (18 species) or water (9 species). This high concentration of rare plants in aquatic habitats illustrates the biodiversity significance of abundant high-quality lakes, streams, and wetlands in the Northern Highland region. Many of the high quality habitats used by rare plants at the NHAL may be vulnerable to invasion by aggressive exotic species such as purple loosestrife, reed canary grass, Eurasian water milfoil, and glossy buckthorn. Preventing the spread of these species would greatly aid the survival of rare aquatic and wetland species at NHAL.

NHAL provides excellent opportunities for assuring the viability of algae-like pondweed, shore sedge, Robbins spikerush (*Eleocharis robbinsii*), and American shoregrass (*Littorella americana*) in Wisconsin, holding the state's largest known populations and large portions of the total number of populations in the state. In addition, NHAL hosts many of Wisconsin's largest known populations of marsh willow-herb (*Epilobium palustre*), leafy white orchis (*Platanthera dilatata*), hidden-fruited bladderwort (*Utricularia geminiscapa*), purple bladderwort (*Utricularia purpurea*), and northeastern bladderwort (*Utricularia resupinata*). Excellent habitat for the above-mentioned plants occurs on the Northern Highland.

A listing of all known vascular plants within the NHAL is provided in Appendix F.

Rare bryophyte species

NHI has a draft list of rare bryophytes, but these taxa are not currently well known at a statewide level. In 1996, NHI undertook a pilot study by contracting Dr. Frank Bowers of the University of Wisconsin – Stevens Point to survey mosses and hepatics. Six sites were surveyed on the NHAL. The rare species *Mylia anomala* (a liverwort, S1, SC) was documented, as well as 4 other bryophytes that are considered rare but have not yet been added to Wisconsin's draft list of rare bryophytes. These include the mosses *Anomodon rugelii*, *Campylium radicale*, *Pseudobryum cinclidioides*, and *Ulota coarctata*.

Rare lichen species

Wisconsin's Natural Heritage Inventory has not formally adopted a list of rare lichen species. In 1996, eminent lichenologist Dr. John Thomson (UW-Madison) compiled a list of lichen species he considers rare in Wisconsin. These are species that are only known from five or fewer places in Wisconsin. In addition, Dr. Thomson highlighted a subset of rare species that show signs of decline in Wisconsin. During the summer of 1996, Dr. Will-Wolf (1996) completed a pilot study for NHI and surveyed the NHAL for lichens. Twelve species from Dr. Thomson's list were found, including two on the subset of rare species: *Hypogymnia tubulosa*, and *Icmadophila ericetorum*.

Rare Animals

Appendix G provides detailed information and lists of rare animals for the NHAL. **Sixty-seven** species of rare animals were documented on the NHAL. This includes one WI Endangered, nine WI Threatened, and 57 WI Special Concern species. Included in these 67 species are one US Endangered (timber wolf) and one US Threatened (bald eagle). The 57 WI Special Concern species found on the NHAL included 20 birds, 19 aquatic insects, 3 mussels, 4 fish, 6 terrestrial insects, 2 mammals, 2 amphibians, and 1 reptile. The NHAL presents a significant opportunity to provide secure habitat for a large number of forest dependent birds including the northern goshawk (*Accipiter gentilis* – WI Special Concern), several boreal species, and many forest interior species. As with rare plants, the high number of rare aquatic animals reflects on the abundance of high-quality lakes, streams, and wetlands in the Northern Highland Region.

Of the 67 species occurring on the NHAL, over 75 percent of the species occur in wetland and aquatic sites. Only 19 (28 percent) occur on upland sites (difference in percentages is due to species occurring in more than one habitat). Though these figures do not convey greater importance of any particular species over another, it

does provide an indication of the importance of protecting wetland and aquatic ecosystems to maintain rare animal species.

Potential timber wolf pack habitat occurs in three main areas of the Forest: 1. areas west of Manitowish Waters, especially the Manitowish River Wilderness and vicinity (~80mi²); 2. areas in the northeast part of the Forest on and adjacent to the Patridge Lake and Frank Lake Wild Areas (~90mi²); and 3. areas on and adjacent to the Indian Creek Wild Area on the southeast side of the Forest (~35mi²). As of 1999, a pack of 2 wolves occurs in the west part of the Forest (Miles Lake Pack), and a pack of 2 occurs on the northeast side of the Forest (Nineweb Lake Pack) (pers. Comm., Wydeven, 1999). The large public land base that the NHAL provides could prove critical for timber wolf restoration in north central Wisconsin, providing road densities are not increased substantially.

The lakes of the NHAL contribute significantly to one of the highest known regional concentrations of bald eagle, osprey, and common loon. Figure 9 shows the distribution of nesting sites for the bald eagle and osprey throughout Wisconsin and the heavy concentration of sites centered on the NHAL area. Detailed, up-to-date records for the eagle and osprey are maintained by DNR Wildlife Management staff at Rhinelander (pers. comm., Ron Eckstein, 1999). The lakes also provide habitat for some of Wisconsin's rarest aquatic invertebrates. See write-ups in Appendix G for: mottled darter, lake darter, black-tipped darter, a caddisfly, subarctic bluet, robust Dubiraphian riffle beetle, a predaceous diving beetle, and the lake emerald dragonfly. Appendix H includes a checklist of all known birds species documented within the NHAL since 1939.

Key Ecological Processes And Attributes

Within the context of the work completed for this project, the key ecological processes of high importance to the maintenance and protection of the natural features on and around the NHAL include:

1. **Natural Disturbance** – Historically, fire was the driving force that influenced vegetation types and patterns throughout the Northern Highlands Pitted Outwash ecoregion. The impacts of long-term fire suppression have significant implications for present and future management and protection efforts. Other important natural disturbances include windthrow, ice storms, insect infestations, plant pathogens, and herbivory.
2. **Hydrology** – Lakes, streams, springs, and wetlands are natural features of the highest importance on the NHAL and surrounding landscape. Important hydrologic processes include rainfall, groundwater recharge, springhead discharge, fluctuations in base level flow, lake levels, and water temperature. The many lakes and wetlands store surface water and release it to streams slowly over extended periods of time. Peak runoff is attenuated and high base flows are prolonged by the basin and wetland storage from the shallow water table, but are reduced during long drought periods. Many of the lakes in this area are classified as sensitive to acid precipitation because of their very low alkalinity. Maintenance, and in some areas, improvement, of water quality and quantity are essential goals.
3. **Natural Succession** – Past land use practices, altered disturbance regimes, and other factors have led to the virtual elimination of older successional stages, a great reduction in several important natural cover types, and the loss of certain plant and animal species from areas they formerly inhabited.
4. **Airshed Characteristics** – We mention this because the Northern Highland Pitted Outwash ecoregion has such a high concentration of soft water lakes. These water bodies are vulnerable to acidification from certain airborne pollutants, and, should this happen, it is likely that there would be a loss or reduction of some of the more specialized and/or sensitive biota now characteristic of the Highlands' soft water lakes.

5. **Immigration/Emigration** – Because of its size and setting, the NHAL presents an excellent opportunity to maintain populations of most, if not all, of the organisms native to the region. This will necessitate careful consideration of the need to create or maintain ecological linkages across administrative boundaries, especially to the west, north, and east.

Key attributes of the present landscape include:

1. **Landforms** – All major landforms of the NHAL are of glacial origin and include uncollapsed outwash, collapsed (pitted) outwash, and end moraine. Lakes and wetlands are especially well represented in each of them. Major drainage systems are the Wisconsin and the Chippewa-Flambeau. Minor landforms include drumlins and bedrock outcroppings.
2. **Soils** – Important soil associations are primarily sands, loamy sands, and sandy loams. Loams are locally prevalent along the southern edge of the end moraine, and loamy sands or loams are common at several locations, often associated with mesic vegetation. Poorly drained organic soils predominate in low-lying areas that intersect or are near the water table.
3. **Vegetation** – Extensive forests cover most of the property and surrounding region, with dry-mesic and mesic types the most widespread. Aspen and plantation-grown pine have replaced the vast pine and hemlock-hardwood forests that historically comprised the bulk of the area's vegetation. Old-growth successional stages and large patches of mature forest are presently rare or uncommon. Conifer cover has been greatly reduced compared to its past extent. Extensive peatlands occur in portions of the region and on the forest.
4. **Representative and rare species** – Water dependent organisms, including many of high management concern such as the bald eagle, common loon and osprey are common in the region. Species associated with extensive forest are also well represented. Some wetlands and lakes are notable for their concentrations and/or large population of rare plants. Several formerly extirpated animals have recently recolonized the forest, including the timber wolf and fisher.
5. **Land use** – Primary land uses are recreation and commercial forestry. Residential growth is high and increasing, especially on lake and stream shores.

Considerations and Ecological Priorities

Key Issues for Consideration

There are 5 key issues that are important for the ecological future of the NHAL and should be considered during master planning. These are not ordered according to importance, but rather are nested within a hierarchy of scales ranging from the regional to the local level.

1. **Content** – The NHAL contains some of Wisconsin's largest and least disturbed remnants of dry-mesic white pine-red pine and mesic hemlock-hardwood forest. Both types comprised the historic vegetation matrix of much of the western Great Lakes "North Woods," and a key consideration should be the protection and management of these communities at suitable locations and at a variety of scales. In particular, the NHAL formerly supported one of the Upper Midwest's greatest pineries, and could do so again. The state forest occupies the heart of the Northern Highlands Pitted Outwash ecoregion (NHAL includes almost 25 percent of the ecoregion), and is therefore especially well suited

to the protection, management, and restoration of this ecoregion's most characteristic forest communities.

Wetlands also deserve conservation emphasis on the NHAL - in particular the extensive peatlands of muskeg, bog, and fen. A diverse array of less extensive natural features are also well-represented on the state forest, including white cedar swamp, hardwood swamp, boreal (rich) fen, emergent and submergent marshes, black spruce and tamarack swamps, bracken grassland, northern dry (jack pine-red pine) forest, and northern sedge meadow.

2. **Size and Context** - At over 220,000 acres, the NHAL is by far the largest state property. It is in close proximity to many other public and private conservation lands. Thus, issues of scale and context are critical and conservation opportunities are available for the NHAL that few, if any, other state properties possess. Opportunities include large patch protection, large-scale restoration of pineries, ecological connectivity, and protection of representative ecological components of the Northern Highlands Pitted Outwash ecoregion. These opportunities could have major implications for future management.
3. **Importance of NHAL at a Variety of Scales** – The NHAL is an important ecological feature at local, regional, and even larger scales. For example, the NHAL provides connections to other properties (local and regional), large forested patches (regional and state), habitat for animals with landscape level habitat needs (regional and state), and critical habitat for both resident and migratory birds (state, multi-state, continental). To implement integrated ecosystem management, the impacts of future management activities at each of these scales should be considered.
4. **Diverse Array of Aquatic Features** - The NHAL presents exceptional opportunities to protect and manage a diverse array of aquatic features. The concentration of glacial kettle lakes within the NHAL is globally important. Some of the lake types are rare, and many rare organisms are supported by the Highland's waterbodies. Important aquatic features include seepage lakes, drainage lakes, spring lakes, spring ponds, small streams, and selected stretches of medium-size streams such as the Manitowish and Wisconsin Rivers. See Appendix D for NHI classification of lakes and streams and type definitions.
5. **Development Pressures** - Development pressures on and around the NHAL are currently high and increasing, especially on the shorelines of lakes and streams (Laas, 1996). Road densities within the forest boundary are high compared to many other parts of northern Wisconsin (WDNR, 1999), and are likely to increase with additional development. This situation lends urgency to the completion of the property master plan, as some current opportunities are unlikely to be available through another planning cycle. Boundary issues deserve especially careful scrutiny in this regard. Identification and prioritization of expansion or coordinated management opportunities should occur during the master planning process.

General Considerations for Master Planning

A number of general considerations for master planning have emerged from the analysis of the ecological processes, biotic data, and existing land use for the NHAL. They are grouped into two categories: considerations related to conservation opportunities and challenges; and restoration opportunities.

Conservation Opportunities and Challenges

1. **Ecosystem Protection** – The NHAL comprises a large portion of the Northern Highlands Pitted Outwash ecoregion. Much smaller portions are in other public ownerships, while the remainder is in private ownership. Thus, the NHAL offers a unique opportunity to protect, restore, and manage the

characteristic features of the Northern Highlands Pitted Outwash ecoregion, including extensive forest, large peatlands, and lakes. The ecosystems within the NHAL provide habitat for plants and animals of local and regional importance, including portions of 2 timber wolf pack areas; regionally high concentrations of bald eagle, osprey, and common loon; and good populations of boreal, forest interior, and area-sensitive birds.

Ideally, site protection design should accommodate natural disturbance events at a sufficient scale so that a single disturbance event would not eliminate the important elements at the site.

2. **Natural Community Protection** - Large patch protection, restoration, and management opportunities are especially important for dry-mesic (white pine-red pine) forests, mesic hemlock-hardwood forests, and large peatlands (muskeg, poor fen, open bog and black spruce/tamarack forests). Among other communities, very good examples occur on the NHAL of northern wet-mesic forest (white cedar swamp), hardwood swamp (black ash swamp), northern dry forest (jack pine-red pine), emergent aquatic (wild rice marsh), northern sedge meadow, shrub-carr, and boreal rich fen.
3. **Existing Forest Cover** - The forests of the NHAL have demonstrated remarkable recovery from the catastrophic logging and other associated major disturbances that occurred in the late nineteenth and early twentieth centuries. However, those forest communities that were formerly most widespread in the NHAL's major ecoregions (dry-mesic white pine-red pine forest in the pitted outwash, and mesic hardwood and hemlock-hardwood forest types on the moraine and to a lesser degree within the pitted outwash) have been greatly reduced in area or strongly altered in character. Individual patches of these natural communities are often isolated from one another. Aspen is currently the most common cover type on the forest, followed by northern hardwoods (mesic forests), natural pine forest, red oak forest, pine plantations, and paper birch (patches of old-growth or older upland conifer-dominated forests of over 100 hectares are now rare throughout northern Wisconsin).
4. **Integrated Site Management** - Some of the sites and features described in the previous section would benefit from management in aggregate rather than separately. An example is Rainbow Wetlands - Swanson Lake and Pines - Big Swamp, in Oneida County. Individually, each of these sites contains very good stands of natural communities that are representative of the Northern Highlands Pitted Outwash ecoregion. These communities in turn support many if not most of the plants and animals typically associated with these respective types, including a number of species that are rare. No single site contains all of the plants, animals, natural communities, and aquatic features characteristic of a northcentral Wisconsin peatland/pine forest landscape. But, by considering the three sites together, many more of these natural features are encompassed, as are large-scale processes.
5. **Boundaries** - The administrative boundaries of the Forest cross the ecological boundaries of some natural features and sites, including forests, wetlands, lakes, and streams. This issue affects lands both within and outside of (but adjacent to) the property boundary. Consideration should be given to identify and secure ecologically appropriate boundaries, through available and suitable options.
6. **High Concentration of Lakes** - The concentration of lakes on the Forest presents a highly significant conservation opportunity, certainly the highest among all state lands for lacustrine ecosystems. However, a significant proportion of the ownership around lakes within the NHAL is in private ownership. This is especially true for large lakes of over 100 acres.
7. **Conservation of Neotropical Migrant Birds** - The NHAL occurs within a band of physiographic strata that supports the highest species richness of breeding birds north of Mexico (Green, 1995). The identification, protection, and appropriate management of significant habitats for this group should be a conservation priority for large public lands in northern Wisconsin.
8. **Dams** - Dams have been constructed on the largest streams within the state forest: the Wisconsin and Manitowish Rivers. These create barriers to the dispersal and other movements of many aquatic

organisms, increase water temperatures, reduce current velocity, and influence water levels in ways that can impact aquatic life.

9. **Land Use** - Development pressures on privately owned lands are currently high and increasing in the region. This is especially true along the shorelines of lakes and streams (WDNR 1996). One consequence of accelerated shoreline development has been the loss of natural vegetation of high value to native animal species. Serious potential consequences include diminished water quality and inadvertent introduction of invasive species.
10. **Fragmentation** - Road densities on the NHAL are high compared to other parts of northern Wisconsin (WDNR(1), 1999). Habitat fragmentation and negative impacts to disturbance-sensitive species are among the management challenges that can result from this condition. As development and human population size increase, associated infrastructure will exacerbate fragmentation-related resource management issues.
11. **Management Conflicts** - Many divergent interests, projects, and goals exist within the NHAL region. State and federal agencies, tribal, county and local governments, and private industry and small landowners may have dissimilar goals (i.e. management goals) based upon their particular interests. Conflicts may exist, both within and outside of the NHAL boundary, which will present challenges for the future management of the NHAL landscape. Tradeoffs are common elements of any implemented management plan. The potential for coordinating management across administrative boundaries should be explored throughout the planning process as appropriate.
12. **Need for Monitoring** – Many controversies have arisen in recent decades regarding the ecological impacts of various management actions. There is a demonstrable need to develop or increase monitoring programs to effectively address these questions. Relevant topics include, but are certainly not limited to, sensitive species trends, changes to water quality and aquatic biota, fragmentation, identification of declining habitats, invasive species trends, and shoreline development issues.
13. **Inventory Results** - The present inventory project has identified and evaluated natural features of many kinds, including natural communities, community complexes, aquatic features, populations of both rare and representative plants and animals, and restoration opportunities that merit careful consideration during the master planning process. For specifics, see succeeding sections, the tabular site summary, and the individual site descriptions in Appendix B.
14. **Inventory Gaps** - No inventory is ever complete, and we do not imply that those taxa we did not include in this effort are unimportant (quite the contrary!). In general, we tried to fill significant information gaps and focused on those communities and taxa where the clarification of status and identification was especially important within the context of the current planning process. A great deal of information already exists, and is available to the planners and the public, for the timber resource, game and certain non-game wildlife species, and fish. Some important but relatively poorly surveyed or understood organisms (e.g., lichens and mosses) received less attention than better known groups because it would be difficult to interpret the results of even a very detailed survey for these taxa within the context of this master plan. Inventory of the NHAL will continue and information will be added on an ongoing basis to the baseline inventory developed for this report.
15. **Dispersed Information** - In the past, it was very difficult to pull together all of the information needed to provide a regional perspective on management opportunities and considerations for a particular property. A series of WDNR reports collectively entitled "Northern State Forest Assessments" is nearing completion and will be available in the future. These reports cover biological topics such as Biodiversity, Community Restoration and Old-growth, and Regional Ecology, as well as socio-economic issues. The information provided in these reports, and in this report, will contribute background information useful for property master planning and other applications.

Restoration Opportunities

Throughout this report we have highlighted natural features of special significance within and around the state forest. Some of these features merit consideration for special management attention based on their rarity, local, regional or range-wide decline, vulnerability, or because they are particularly representative of this landscape. We are treating “restoration” as an issue for master planning in those cases where we have identified opportunities and established need, where restoration in proximity to other natural features of significance would confer ecological benefits to that feature (or site), or when few other opportunities to achieve the restoration of a given feature exist in either the local or regional landscape. It is important to note that 1. We do not imply that restoration means a return to presettlement conditions, but rather that communities, species, structural features, microhabitats, and natural processes that are diminished in, or now absent from, the present landscape have a valuable role to play in maintaining our native ecosystems; and 2. Tried and true methods for the restoration of whole forest communities do not exist. All such actions should be regarded as at least somewhat experimental, and monitoring of the responses of vegetation, and perhaps selected species, must be an integral part of such an endeavor.

1. **Restoration Potential** - Much of the land that has been intensively managed for forest products in recent times has some potential for the restoration of lost or diminished species, structural features, successional stages, ecological connections, or other attributes. It is important to select candidate sites for restoration with respect to their size, context, and ecological appropriateness, and to identify project objectives as clearly as possible. Methods to be used in restoration should be clearly conveyed to relevant parties.
2. **The Pinery** - This report identifies a subset of sites where white and/or red pine restoration is appropriate now or in the near future. DNR's various assessment teams have identified broader areas, using a combination of existing land cover (e.g., forest reconnaissance and satellite imagery) and habitat type information, where conditions are suitable for pine restoration. What's less readily available is the identification and location of stands typed by their current canopy cover (usually aspen or paper birch or occasionally as oak) but with a strong component of pine in the understory. Pinpointing those stands with a significant understory pine will greatly increase the success of a restoration effort. Working with the Bureau of Forestry, we recommend the use of infrared aerial photography, under leaf-off conditions, over and around the most suitable areas already identified as having the best restoration opportunities.
3. **Stream Restoration** - Dams impact the biodiversity of streams, especially affecting fish, mussels, and certain aquatic insects. Removal of some dams would provide an opportunity to restore various aquatic biotic and stream functions.
4. **Wildlife Restoration** - The size of the property is adequate for most area sensitive species such as timber wolf and moose, especially if forested and roadless (or lightly roaded) corridors are maintained between the NHAL and the large public holdings surrounding. The draft timber wolf management plan identifies parts of the NHAL as primary habitat and much of the rest as secondary habitat. This primary and secondary habitat area is an island surrounded by unsuitable habitat for wolves and is critical as a connection to forested habitats in northcentral and northeastern WI.

Ecological Priorities

The Bureau of Endangered Resources bases the following ecological priorities on careful scientific analysis. They reflect assessment and inventory of the region surrounding the NHAL as well as the property itself. They are organized around a number of primary issues: management and protection, restoration, land use, and monitoring. This information was developed for the Department's master planning team who will use these ecological priorities, along with other information, to help develop

overall recommendations for the Forest. Research and inventory priorities are also listed, although they may be more useful in identifying follow-up actions to master planning. Site-specific information and considerations are provided in the site description section (Appendix B).

Primary Site Management and Protection

1. The 65 primary sites and 4 macrosites represent selected inventory sites within the NHAL that contain the best examples of rare and representative natural features that were documented. They encompass a broad array of natural communities, aquatic features, rare plant and animal populations, and restoration candidates. The following attributes may be used to help identify and prioritize these ecological priorities:
 - a. Communities that are rare everywhere in the region or state.
 - b. Communities and community complexes that are better represented on, and especially characteristic of, the NHAL.
 - c. Successional stages of widespread forest communities that are poorly represented in the current landscape.
 - d. Rare species that are represented by large, potentially viable populations, and are better represented on the NHAL than on other properties in other regions. Isolated, small, or disjunct populations of rare species should be treated on a case by case basis, and protected as deemed appropriate and feasible.
 - e. Aquatic features representative of the pitted outwash and Winegar moraine ecoregions. Some of those present on the NHAL are uncommon or absent elsewhere in the state.
 - f. Aquatic features that are rare throughout the state and region.
 - g. Select restoration candidates with respect to need, opportunity, and especially, context. These candidates should focus on:
 - sites that link or could link now-separated patches of existing communities or aquatic features of high ecological significance.
 - sites with good potential to reduce high-contrast edge and associated negative edge impacts - sites that would increase the effective stand size of small high-quality forest patches.
 - sites that would create or enhance dispersal or travel corridors.
 - sites that could create appropriate linkages with natural features beyond the boundaries of the NHAL.
2. The local and regional significance of each primary site is summarized in Table 2 on page 17. Of the 65 primary sites, 36 sites, including all four macrosites, are ranked “high” in all of BER’s evaluation categories at both the property (local) and statewide (regional) levels. Basic ranking criteria include current quality and condition of the natural communities and aquatic features, size of the natural communities, the representation of both rare and characteristic species, context of the sites, and the degree of effective protection afforded these natural features statewide.

Catherine Lake Hemlock-Hardwoods (1)

Lower Manitowish River Macrosite

- North Bass Lake and Hemlocks and Bog (2)
- Du Page Lake and Pines (3)
- Sugar Lake (Plunkett Lake) (4)
- Manitowish River Wilderness Area (5)
- Sandy Beach Lake and Bog (6)

Sherman Lake (7)

Toy Lake Cedar and Ash Swamp (8)

Rice Creek Complex (10)

Manitowish River (12)

Day Lake (13)

Northeast Springs - Johnson Creek Macrosite

- Johnson Lake and Barrens (18)
- Johnson Creek and Pines (19)

Nixon Lake Complex (20)

Star Lake Crescent Macrosite

- Lake Alva Hemlock-Hardwoods (22)
 - Lake Laura - Salsich Lake (23)
 - Plum Lake Hemlock Forest (24)
- Aurora Lake and Wetlands (26)
 - Central Highland Macrosite**
 - Escanaba Lake Hemlocks (31)
 - Lost Canoe Hardwoods (32)
 - Stevenson Creek and Pines (33)
 - Allequash Lake and Pines (34)
 - Little John Junior Lake (35)
 - Benedict - Hurrah - Scaffold Lakes Complex (36)
 - Dry Lake and Pines (37)
 - Bittersweet Lakes Complex (38)
 - Mud Creek Springs (39)
 - Sweeney Lake Area (40)
 - Trout River (41)
 - Camp Lake and Pines (44)
 - Devine Lake - Mishonogan Creek (45)
 - Wind Pudding Lake (57)
 - Rainbow Wetlands (60)
 - Big Swamp (61)
 - Swanson Lake and Pines (62)
 - Shallow Lake (64)

It is important to note that protection and restoration opportunities for the NHAL are not and should not be limited to the sites above – rather, they provide opportunities to achieve a basic level of protection for the rare and representative species, natural communities, and aquatic features of the NHAL. The remaining 29 primary sites all support features of relatively high ecological value, but conservation opportunities are somewhat limited by stand size, adjacent land use, ownership, or some other factor. However, these 29 sites should be considered carefully for the most appropriate land use classification, as some community types do not presently occur at large scales, may be lacking older successional stages, or are represented everywhere in the Wisconsin landscape only by very small or degraded examples.

In the case of restoration sites, we expect that information will be forthcoming from the DNR's Community Restoration and Old-growth interdisciplinary team and will identify additional restoration opportunities appropriate for the NHAL.

3. Land Management classifications have been established per Chapter NR44 of the Administrative Code for the Department of Natural Resources. The classifications are used in developing, revising, and amending master plans. The 65 primary sites and 4 macrosites should be considered for an appropriate classification with the objectives of:
 - Ensuring habitat needed for rare and representative endangered resources (natural communities, aquatic features, and rare species)
 - Restoring and perpetuating native communities

In some cases, management considerations (provided with site descriptions in Appendix B) suggest limitations, guidelines, or special responsibilities in the development of land management decisions.

4. The above 36 high significance sites are referenced in the text in Appendix B by the term “strong protective designation.” This term highlights the need for strong habitat and native community protection because of their ecological values. From a BER standpoint, these 36 sites are of comparable significance

to existing SNAs, and may represent ecological components that are missing or underrepresented from the existing SNAs. Official designation and state natural areas will be determined through the master planning process and other formal review, such as Natural Areas Preservation Council (NAPC) review.

There are currently thirteen designated SNAs on the NHAL totaling 2,206 acres. A variety of natural features occur within these sites, but they are typically small and at least somewhat isolated by land uses on adjacent tracts. The largest of these, Bittersweet Lakes, is 568 acres. 275 acres of this SNA is second-growth upland forest, the rest open water and wetland. Despite the very low representation of old-growth or older forest on the SNAs statewide, the state's largest stand of old-growth occurs at Plum Lake Hemlock Forest SNA on the NHAL and totals slightly less than 200 acres. Larger old-growth stands are not known on any other state, federal, or county lands anywhere in Wisconsin.

5. Specific management and protection considerations for rare species, natural communities, and aquatic features at each site are provided in Appendix B.
6. General recommendations and management considerations for natural communities, rare plants, and rare animals are provided in Appendices D, E, and F.
7. Issues of scale and context warrant careful consideration when making future land use decisions on the NHAL. These issues should be considered for all sites identified in our report, as well as sites proposed for restoration. At some locations, restoration could create additional ecological benefit if restoration areas were extended beyond primary survey site and macrosite boundaries. Additional opportunities should be considered as they are identified or as conditions on or around the NHAL change.

NHAL Management and Protection

1. Protect large undeveloped and unmanaged lakes, as these are becoming a scarce resource in Wisconsin. The NHAL represents one of the few opportunities to preserve a meaningful number of lakes in this condition.
2. Protect existing stands of late successional and old-growth forest where appropriate and identify potential sites for old-growth restoration. At present in the NHAL landscape and throughout the remainder of Wisconsin, old-growth forests are rare, large patches of old-growth forest are nonexistent, and large patches of older, maturing, closed canopy forest are uncommon. Existing old-growth stands are generally isolated and limited to small patches. Large diameter trees, large snags, a multi-layered canopy, coarse woody debris, and certain late successional species are among the attributes that typically characterize old-growth forests. These forests support assemblages of plant and animal species, structural elements, and ecological processes not found in younger aged stands (White, 1994).

The NHAL contains several primary late successional upland forest community types, including mesic hemlock-hardwood forests and dry-mesic to dry white and red pine forests. Examples of protection opportunities for existing old-growth mesic hemlock-hardwood stands include Catherine Lake Hemlock-Hardwoods (#1), Du Page Lake and Pines (#3), and Star Lake Crescent Macrosite (including Lake Alva Hemlock-Hardwoods (#22), Lake Laura-Salsich Lake (#23), and Plum Lake Hemlock Forest (#24), the largest known old-growth hemlock stand in the state). Examples of protection opportunities for existing old-growth dry-mesic stands include Lower Manitowish River Macrosite (including Manitowish River Wilderness Area (#5)), Central Highlands Macrosite (including Dry Lake and Pines (#37)), Two Lakes Pine-Oak Forest (#56), and Stone Lake Pines (#65). In addition to existing stands, other sites provide additional opportunities for restoration of late

successional or old-growth forests, including Camp Lake and Pines (#44), Mud Creek Springs (#39), and Vandercook Lake and Pines (#47).

3. Though still common in northern Wisconsin, peatlands have been increasingly vulnerable to certain types of development and merit additional protection. The highest protection priorities should be extended to stands that are large, functionally intact (especially the hydrology), support significant diversity, and are ecologically connected to other important natural features. Examples on the NHAL include Lower Manitowish River Macrosite (including Sandy Beach Lake and Bog (#6)), Mud Creek Springs (#39), Rainbow Wetlands (#60), and Big Swamp (#61).
4. Consider adjusting boundaries that presently impede the ability to appropriately protect and manage a given feature.
5. Establish a plan for identifying and implementing protection priorities on lands not owned by the state, including acquisition, conservation easements, cooperation and coordination with other agencies, organizations, and private individuals, and other methods. High protection priorities could include:
 - a. shoreline areas
 - b. key inholdings, especially where there are identified natural features of significance and the potential for incompatible use or development exists
 - c. lands with high restoration potential, especially in close proximity to identified natural features of significance
 - d. lands that would create ecological linkages across administrative boundaries between sites with significant natural features
6. The term “active management” encompasses activities such as timber production, site preparation, prescribed burning, trail maintenance, fish stocking, exotic species removal, and many others. For a number of sites described in Appendix B, active management is not necessary in the near future to maintain certain species or natural communities. However, depending upon changes from colonization by invasive species, successional processes, site conditions, and many other factors, some active management activities may be required in the long term.
7. Consider long term aquatic ecosystem management when developing management plans for aquatic systems. Stocking of fish species not normally present or abundant enough to provide a sustained sport fishery occurred in many of the lakes on the forest that are large and deep. Chemical treatment (eradication) of fish to change the species composition and to favor the stocked species has been conducted on relatively few NHAL lakes. These practices alter the aquatic fish community for varying lengths of time. Successful fish eradication affects all fish species including non-targeted species. Nearly all mussel species are dependent on one or more fish species to complete their life cycle and as a result could be affected by the alteration of the fish community. Some aquatic insects, including some Special Concern species, are dependent on the absence of fish in the waterbodies they breed in. At least one Special Concern species, the lake herring, is thought to have declined in part because of stocking of muskellunge, rainbow smelt, and walleye.
8. Continue to provide Endangered Resources information to land and water managers in the field. Increase the use of information on the locations, management needs, and sensitivities of rare plants and animals that could be impacted by habitat modifications.
9. Plan for unanticipated disturbance events or advances in management techniques by establishing benchmarks and applying adaptive management principles. Experimental techniques could be developed and accompanied by long-term monitoring of effects.

Restoration

Key factors to consider in all restoration projects include context, the reduction of high-contrast edge and linear stand configuration, and the benefits of creating or expanding ecological linkages between existing high quality remnants (including restoration, where feasible, across administrative boundaries).

Note that not all restoration opportunities have been identified on our “Primary Survey Site” map (Figure 6) and additional locations will also merit consideration. We recognize that not all of these sites will be the focus of restoration, that it will take years before it is feasible to proceed with some restoration activities, and that the results may be difficult to interpret for many decades.

1. Pursue the restoration of dry-mesic white pine-red pine forests at locations within the Northern Highland Pitted Outwash ecoregion. Red oak should be considered an important component of restoration efforts at some localities. Restoration at varying scales is possible, and is especially needed to address the absence of larger patches and older successional stages of this formerly widespread community. The restoration of more natural whole communities dominated by pines is perhaps most desirable at this time in areas adjoining relatively intact remnants of this forest type. At other locations, the primary considerations could include restoring certain community attributes such as increased conifer cover, increased forest patch size, larger trees, and allowing for the development of snags, coarse woody debris, and other features. Sites known to harbor invasive species (e.g., the heavy infestation of purple loosestrife in some wetlands on the Minocqua Chain of Lakes) could also be considered within the category of ecosystem restoration.

Potential high priority restoration areas include but should not be limited to:

- a. areas around (as well as within) the “Central Highlands Macrosite”
 - b. areas around (and within) the “Lower Manitowish River Macrosite”
 - c. along the entire northern border of the state forest, linking primary survey sites with the extensive forests to the north
 - d. areas around and between “Rainbow Wetlands,” “Big Swamp,” and “Swanson Lake and Pines.”
2. Consider restoration opportunities for dry forest in the vicinity of the “Northeast Springs Macrosite,” “Boulder Flats Plantations,” and “Rainbow Wetlands.” Dry forests of jack pine and/or Hill’s (northern pin) oak are quite limited on the NHAL but this type is declining statewide and many stands have been converted to red pine plantations in recent years.
 3. Consider the restoration of mesic hardwood and hemlock-hardwood forests in the vicinity of three important sites in the NHAL: “Star Lake Crescent Macrosite,” Central Highlands Macrosite,” and “Catherine Lake Hemlock-Hardwoods.” Several smaller sites also contain good examples of this community but at a greatly reduced scale. Stands containing a significant amount of hemlock are vulnerable to excessive browse by white-tailed deer, and the restoration of forest types less likely to support high deer densities, where appropriate and feasible, is an important consideration for managers of such sites. Hemlock reproduction is spotty throughout the NHAL, locally strong, but overall quite poor.
 4. Develop a restoration proposal for tamarack swamp communities. Some evidence has indicated that tamarack, especially stands composed of large trees, may have been significantly reduced in the region since European settlement (WDNR 1999, CROG report in progress). For the time being, adherence to a philosophy of strong wetland protection may be the best course of action.
 5. A number of sites on the NHAL are currently managed intensively for timber production, yet offer a range of ecological values (and thus restoration potential) including extensive conifer cover and habitat for conifer-dependent forest-interior animals. The forests of Boulder Flats and Papoose Creek

Pines are examples of large sites currently in partial plantation cover that offer long-term restoration potential towards a natural conifer-dominated landscape.

6. Consider stream and stream bank restoration for stretches of the Wisconsin, Manitowish, and Trout Rivers. Efforts should be focused on areas known to support significant diversity of aquatic life and where negative impacts exist from past or present land use.
7. There are currently 2 wolf packs using the NHAL as part of their occupied habitat. Because of the large average size of wolf territories (ranging from 20 to 120 mi²), no pack territory is likely to be completely contained within the forest, and some areas of suitable habitat may not be fully occupied. Linkages from the NHAL to other surrounding properties are important to maintain populations of timber wolf in the northcentral Wisconsin landscape.

Land Use

1. Develop a long-term plan to assess the impacts of development and future land use on the natural communities of the forest. Primary uses of the forest and surrounding lands include recreation, timber production, limited agriculture (cranberry and wild rice production), and residential development. Private lands within and around the state forest are experiencing increasing development pressure. All of these uses impact the natural communities of the NHAL and their long term sustainability.

Monitoring

The following suggestions comprise an initial list of monitoring needs. We realize the Department is limited in its ability to undertake these actions immediately, but we feel that it is important to identify issues now within the context of a new planning cycle. These suggestions should be factored into master planning to help develop an overall monitoring plan. Final priorities should reflect the preferred alternative selected through master planning.

1. Identify a selected subset of rare, sensitive, highly specialized, or otherwise appropriate plant and animal species which are important in the Northern Highland landscape and design a monitoring project to measure changes over time.
2. Develop monitoring protocols to measure the responses of both target and non-target species to various management activities. The same should be done for all restoration projects and at least a subset of natural communities.
3. Develop a coarse scale monitoring protocol to measure changes over time in patch size distribution, cover type representation, successional stage representation, and development in and around the NHAL.

Research

Inventory is an ongoing endeavor, with new efforts adding information to the baseline established for this report. In general, the following research needs and information gaps will not have significant impacts on the development of a new master plan for the state forest.

1. Conduct additional research on methods of reducing browse pressure on sensitive species such as eastern hemlock and white cedar. The development of effective restoration methods for these species is an important application of such research.
2. Conduct research on the long-term impacts of fire suppression on dry and dry-mesic forest communities, bracken grasslands, and sedge meadows.

3. Establish standardized breeding bird surveys in important sites and community types throughout the NHAL.
4. Complete the descriptions of the Land Type Associations (LTAs). More detailed ecoregional information is needed to sufficiently describe and analyze the lands of the NHAL and apply this information to other data sets including rare species, community types, aquatic features, and others.

Future Inventory

1. Complete surveys on the extensive peatlands that occur north of the Manitowish River, just west of USH 51 and the village of Manitowish Waters. An aerial reconnaissance was conducted here and the vegetation appears to be in excellent condition. No immediate threats were noted.
2. Further investigate the semi-open lands north and west of Papoose Creek Pines. It is uncertain whether the vegetation structure here is due solely to past attempts at agriculture. A wetland separates this area, characterized by scattered trees and herbaceous or shrubby openings, from the old field to the west. It shouldn't be assumed that all of this land shares the same land use history without further investigation.
3. Extensive wetlands occur between White Sand and Nixon Creeks in Vilas county, T42N-R7E-secs. 21, 22, and 23. A number of small undeveloped seepage lakes (kettle bogs) are found in this area. Surveys should be conducted here prior to the implementation of management activities that would alter the vegetation structure, composition, or hydrologic function of these features.
4. Conduct additional fieldwork at Partridge Lake, Partridge Creek and wetlands, McGinnis Creek and wetlands, and the uplands between Partridge and Ballard Lakes prior to the implementation of management actions.
5. Inventory scattered wetlands not surveyed on the Forest. In general these are small, somewhat isolated sites, often within intensively managed uplands. Some of these wetlands are identified in the Primary Survey Site Description section (e.g. Wharton Lake Bog Complex).
6. Conduct additional survey at Sweeney Lake and its adjoining wetlands. We recommend that no drastic management actions occur here until such surveys are completed.
7. Conduct additional fieldwork on bryophytes and lichens throughout northern Wisconsin.
8. Conduct further surveys for the state endangered little goblin moonwort (*Botrychium mormo*) on the NHAL and determine its significance to the statewide status of this species. Though not confirmed on the NHAL, this plant was tentatively identified from a fragment collected in a mature mesic hardwood forest near Lake Laura in September of 1995. In addition, it is found in abundance just east of the Forest. Recent discoveries of this plant in other parts of the state have raised the question of the actual status of this plant in Wisconsin.
9. Identify exotic/invasive species issues relevant to the NHAL and devise management strategies as appropriate.
10. Additional inventory is needed for the Powell Marsh area, Big Swamp, and other large peatlands. These areas represent wetland types with great potential to support a number of rare species including dragonflies, butterflies, moths, and birds.
11. Conduct additional surveys of Lepidoptera (butterflies and moths). There is excellent potential on the NHAL for boreal leps because of the extensive high quality peatlands on and around the state forest. Note that a number of peatland sites were identified for careful management and protection consideration in this report. Future surveys should be done to better establish the status of boreal wetland lepidoptera in the state.

12. Conduct additional fieldwork on non-game fish and other selected aquatic organisms.

Glossary of Terms Used in This Report

aquatic macrophyte - vascular plants with special adaptations to aquatic habitats (lakes, streams, springs).

bog - wetlands characterized by high acidity, the accumulation of sphagnum moss peat, and a group of highly specialized vascular plants that includes ericaceous shrubs (e.g., leatherleaf, bog laurel, cranberries), sedges, and insectivorous species. By the strictest definition, a bog can receive nutrients only from precipitation, and is isolated from mineral enriched groundwater by thick beds of living sphagnum mosses and partially decomposed moss peat. “Open” bogs are those lacking a dense overstory of coniferous trees. Forested, or treed, bogs support a relatively dense growth and correspondingly closed canopy of black spruce, sometimes mixed with tamarack. See “*muskeg*.”

complex – used here to reference an integrated mosaic of natural communities and/or aquatic features.

cover type – Cover typing is a generalized but sometimes useful method of broadly classifying vegetation based on the single species or species group comprising a majority of the living plants (usually commercially important trees when used in a forestry context). Cover types may also reference cultural features such as cornfields or pastures (“grass”). In cases where a clear plurality of a single species is not apparent, terms have been invented to reference groups of commonly co-occurring species, such as “northern hardwoods” (see definition below), and “swamp conifers.”

diversity - used in this report as a shortened form for biological diversity, or biodiversity. A general definition (Matthiae et al., 1993) is "the spectrum of life forms and the ecological processes that support and sustain them. Biological diversity is a complex of four interacting levels: genetic, species, community, and ecosystem."

drumlin - streamlined, teardrop shaped hills created by glacial action. The long axis parallels the direction of past glacial movement.

ecoregion – geographic units that are differentiated by climate, subsurface geology, physiography, hydrology, soils, and vegetation. These units have been defined and organized in different ways by various institutions but in this document we use the National Hierarchical Framework of Ecological Units (NHFEU). As described by Avers et al (1994), the NHFEU can provide a basis for assessing resource conditions at multiple scales. In this report we have most frequently referred to ecoregions of the “subsection” level, which are intermediate in scale within the NHFEU and typically cover areas of hundreds to thousands of square miles. In recent years the NHI has found the ecoregions of the NHFEU to be useful tools for work planning, interpreting the collected data, and communicating across political and administrative boundaries.

element –the basic building blocks of the Natural Heritage Inventory. They include natural communities, rare plants, rare animals, and other selected features such as colonial bird rookeries and mussel beds. In short, an element is any biological or ecological entity upon which we wish to gather information for conservation purposes.

element occurrence – an individual example of an element (a natural community, a rare plant population, a rare animal population, or other feature tracked by the Natural Heritage Inventory program) at a specific geographic location.

ericaceous – pertaining to a family of plants, the Ericaceae, especially characteristic of highly acidic habitats such as bogs and muskeg. Members include well-known plants such as blueberries, cranberries, leatherleaf, Labrador tea, and bog rosemary.

exemplary – used in this report to describe aquatic communities or organismic assemblages that are especially good representatives of their respective types. Usage of the term, while somewhat subjective, entails a comparison of like entities based on their diversity, water quality characteristics, disturbance history, and values to scientific study.

fen - wetlands that receive nutrients via direct contact with mineral enriched groundwater. A "poor" fen has very low concentrations of plant nutrients and floristically resembles a bog. A "rich" fen has relatively high concentrations of nutrients, but is still characterized by the accumulation of peat (though this is likely to be primarily from the remains of plants other than sphagnum mosses, such as sedges and brown mosses). While some plants tolerate, and in fact may thrive under, a wide range of conditions, others are quite restricted and typically occupy only a narrow range of nutrient concentrations. This last group can be useful in the identification of peatland communities.

fragmentation – the breaking up of large and continuous ecosystems, communities, and habitats into smaller discontinuous areas that are surrounded by altered or disturbed lands or aquatic features.

habitat – references those environmental attributes necessary to provide a niche that supports the needs of a species or group of species.

habitat type – all sites capable of producing similar climax plant communities. This system uses the floristic composition of a plant community as an integrated indicator of those environmental factors that affect reproduction, growth, competition, and community development. These include soils, moisture, nutrient levels, and topography. Some professional foresters in the upper Great Lakes region have begun using this system as a forest management tool. To date, this system has been developed primarily for upland forest communities.

inventory site - also "site" in text. The geographic location at which a biological survey has been conducted. These may be large or small, depending on the nature of the species or community surveyed. Boundaries may be finite and discrete (a property boundary, a single stand of a forest community), or rather arbitrary. When sites become very large (exceeding several thousand acres) and encompass complex landscapes, they are sometimes referred to as "macrosites" (see below).

landtype association (LTA) - this level in the ecoregional hierarchy covers areas of tens to thousands of acres. Landform, soils, and vegetation are the key factors.

lentic – pertaining to standing waters, lakes.

lotic – pertaining to flowing waters, rivers.

macroinvertebrate - Used in the report to refer to aquatic insects and mollusks.

macrosite – two or more standard survey sites in close proximity, where consideration of their collective attributes is in some way related to the viability ecological values of the larger site.

matrix - used in this document to refer to the dominant land cover within which other features of the landscape are embedded.

mesic - used by ecologists to describe site conditions that are well-drained but almost never excessively dry or inundated.

moraine - landforms composed of unsorted materials deposited by glaciers. They can cover broad geographic areas of millions of acres. Topography can vary from nearly level "till" plains to rough end moraine landscapes composed of steep dry ridges interspersed with deep kettle holes. These glacial "kettles" are frequent locations for lakes and wetlands.

muskeg – similar to "open bog." Used to describe highly acidic peatlands characterized by a sparse growth of scattered, stunted black spruce and tamarack over ericaceous shrubs, sedges, and a deep carpet of sphagnum mosses.

National Hierarchical Framework of Ecological Units (NHFEU) – a land unit classification system developed by the U.S. Forest Service and many collaborators. As described by Avers et al (1994): “The NHFEU can provide a basis for assessing resource conditions at multiple scales. Broadly defined ecological units can be used for general planning assessments of resource capability. Intermediate scale units can be used to identify areas with similar disturbance regimes. Narrowly defined land units can be used to assess specific site conditions including: distributions of terrestrial and aquatic biota; forest growth, succession, and health; and various physical conditions.”

natural community – an assemblage of plants and animals, in a particular place at a particular time, interacting with one another, the abiotic environment around them, and subject to primarily natural disturbance regimes. Those assemblages that are repeated across a landscape in an observable pattern constitute a community type. No two assemblages, however, are exactly alike.

natural division – six major natural divisions have been delineated for the state of Wisconsin based on gross differences in vegetation, soils, and geomorphology. Recent collaborative work by the USDA Forest Service, The Nature Conservancy, the WDNR, and others has resulted in a somewhat similar but hierarchical classification system of “ecoregions.”

Natural Heritage Inventory – A system developed by the Science Division of The Nature Conservancy for collection, management, and use of biological, ecological, and related information. In Wisconsin, the Natural Heritage Inventory was established by an act of the state legislature in 1985, after which the program was installed within the WDNR’s Bureau of Endangered Resources.

northern hardwoods –generally applied to those forests of northern Wisconsin composed primarily of hardwoods such as sugar maple, basswood, ash, and birch. It is also sometimes used to refer to forests with a significant component of red maple or red oak, or sometimes even aspen, but which lack strong representation by coniferous species. The term is also in wide usage in Michigan, northern Minnesota, and other locations that have vegetation similar to that of northern Wisconsin.

old-growth – various definitions exist, but among the points they usually share in describing old-growth attributes are large living trees, standing snags, coarse woody debris, pit and mound microtopography, and complex multi-layered canopies. Old-growth stages of many forest types were formerly common and/or widespread in northern Wisconsin but are now very rare (Frelich, 1995).

outwash - composed of materials sorted and deposited by glacial meltwaters. The resulting topography can be a level plain (“uncollapsed”) or very hilly (“collapsed” or “pitted”). Pitted outwash may contain numerous lakes, which originated when blocks of ice stranded by a receding glacier were buried within outwash deposits. As the ice melted, depressions were created that filled with water. This is the most extensive landform found on the NH-AL SF.

peat – organic deposits consisting of the partially decomposed remains of plants, which accumulate over time more rapidly than decomposition processes can break them down. Peat may be derived from the remains of mosses, sedges, or woody plants.

peatland –wetlands characterized by the gradual accumulation of peat, the partially decomposed remains of plants. Open bog, muskeg, black spruce swamp, tamarack swamp and poor fen are among the common peatland communities on the NH-AL SF.

pinery - because pine played such an important role in the European settlement of northern Wisconsin, those areas that supported extensive forests of white and red pine were called "pineries" by nineteenth century European settlers and loggers. The area now occupied by the Northern Highland State Forest was the heart of one of the upper Midwest’s most notable pineries.

Pleistocene – in the geologists parlance, “the first epoch of the Quaternary Period.” In more common usage, the Ice Age. The topography, soils, and drainage patterns of the Northern Highland landscape were strongly influenced by glaciation, which last occurred in this area approximately 12,000 years ago.

poletimber – a forestry term referring to living trees of at least 5” d.b.h., but less than 9” d.b.h. for softwoods such as aspen and pine, or less than 11” d.b.h. for hardwoods such as sugar maple, yellow birch, or ash.

Potential pack habitat – areas that have greater than a 50 percent probability of being settled by wolf packs (Mladenoff et al., 1995). Such habitat would be heavily forested, have few people, and have a density of improved roads of <0.7 mi/mi². Winter pack wolf territories on the average cover 50 mi², but can range from 20 – 120 mi².

rare– used in this report to refer to native species and natural communities known or suspected to be rare and/or declining in the state (included on NHI’s “Working List”). Included are species legally designated as “Endangered” or “Threatened” by either the State of Wisconsin or the federal government, as well as species in the Department’s advisory “Special Concern” category and on the U.S. Fish & Wildlife Service’s “Candidate” and “Species of Concern” lists.

restoration – used in this report to refer to the re-establishment of a natural community, habitat, species population, or other ecological attribute, that has been eliminated or greatly reduced on a given property or landscape. Many factors, sociological as well as ecological, must be weighed when making a decision to engage in a restoration project.

sawtimber – a forestry term referring to living trees of at least 9” d.b.h. for softwoods such as aspen or pine, or of at least 11” d.b.h. for hardwoods such as sugar maple, yellow birch, or ash.

site – see “survey site.”

State Natural Area - formally designated sites that contain outstanding examples of native biotic communities and are often the last refuges in the state for rare and endangered species of plants and animals. Areas are devoted to scientific research, the teaching of conservation biology, and especially to the preservation of their natural values and genetic diversity for future generations. The Department of Natural Resources currently administers 326 State Natural Areas encompassing more than 120,000 acres of land and water.

sterile rosette – used to reference a distinctive and highly specialized flora found primarily in lakes with extremely soft, circumneutral water, and firm substrates. Examples of the plants comprising this group include American shoregrass, water lobelia, quillworts (*Isoetes* spp.), pipewort, and brown-fruit rush (*Juncus pelocarpus*).

survey site – The geographic location at which a biological survey or evaluation has been conducted. Survey sites may be large or small, depending on the nature of the species or community surveyed and other factors. The boundaries of a survey site may be finite and discrete (a property boundary, the margins of a single stand of a natural community, or even the limits of a rare plant population) or rather arbitrary. When sites become very large (exceeding several thousand acres) and encompass complex landscapes they may be referenced as “macrosites.”

Subsection – This is a level in the NHFEU that is intermediate in scale. Subsections are characterized by distinctive glacial landforms (e.g., outwash or moraine), soils, and broadly, by vegetation. Two ecoregional subsections, the Northern Highlands Pitted Outwash and the Winegar Moraines, are represented on the NH-AL SF.

TNC - The Nature Conservancy, a private conservation organization responsible for developing the standardized methodology used by Natural Heritage programs. The Wisconsin Chapter has actively worked for many decades with private landowners in the Bois Brule watershed to secure conservation agreements.

xeric – characterized by excessive dryness.

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